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Hierarchical method using ethnographic data sets to guide archaeological research: Testing models of plant intensification and maize use in Central Western Argentina

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ABSTRACT

Ethnographic and environmental data sets developed by Lewis Binford are used to test models about the relationship between forager plant intensification and maize adoption in Central Western Argentina. By examining large suites of cases to identify regular patterns of association, the models describe regular interactions that are apparent in the patterning across known groups. To the extent that people in the past adapted in similar ways to environmental and demographic conditions as people recorded ethnographically, they may be expected to fall within the bounds of general ecological relationships.

1. Introduction

Archaeological interest in prehistoric farming in the Americas has focused primarily on questions surrounding the wild origin, domestication, spread, and cultivation of maize (*Zea mays*). Through such research, we have learned that maize was prehistorically domesticated in south central Mesoamerica (Benz, 2006; Benz and Staller, 2006; Blake, 2006; Pearsall, 2008; Ranere et al., 2009; Staller, 2010) and that from there, maize cultivation spread across many parts of North and South America. While the mechanisms that drove the prehistoric dispersal of maize cultivation are hotly debated, the fact that prehistoric maize spread over thousands of kilometers and into diverse environmental zones in both North and South America is remarkable (Merrill et al., 2009; Staller et al., 2006; Pearsall, 2008). Given the phenomenal spread of prehistoric maize, the absence of maize in many areas is often overlooked. However, equally remarkable is the fact that maize cultivation was not adopted prehistorically in many parts of both South and North America which are adjacent to areas where it was used. Prehistoric evidence of maize cultivation, and farming practice in general, is conspicuously absent from much of modern day Argentina, the Western United States, the South Central United States and Northern Mexico (Bettinger and Wohlgemuth, 2006; Johnson and Hard, 2008; Politis, 2008; Simms, 2008).

Both the initial cultivation of maize and the large-scale adoption of horticultural strategies are processes through which hunter–gatherer subsistence is transformed into horticultural subsistence. To fully explain why hunter–gatherers begin to practice horticulture in some places, we must also be able to explain why they do not adopt this strategy in other places. We do not argue that horticulturalists never migrated, taking horticulture with them; just that much of the process of the adoption of agriculture depends on choices made by hunter–gatherers. Nor do we argue all American horticulture was like maize horticulture. Focusing on maize provides a convenient control on the domesticates while exploring the utility of global scale macroecological models. Since each plant that is domesticated (e.g. maize, beans, squash, potatoes, quinoa) may be limited by a different set of ecological conditions this simplification of reality gives the model it's value. Where our model is too simple, there will be variation left unexplained that will drive future research. Here we explore a hierarchical method (following Johnson, 2013) for using ethnographic data on hunter–gatherer and horticultural subsistence to guide archaeological research on the variation in maize use in Central Western Argentina. This contribution is one small step toward the challenge of explaining and testing explanations of prehistory identified by Kelly (2015) as the remaining challenge for 21st C archaeologists inspired by Childe and Binford.

Central Western Argentina, (30–40°S, 67–70°W) provides rich opportunities to investigate the prehistoric presence and absence of maize cultivation. The archaeological and ethnohistoric records from this region indicate that maize use over the last 2000 years varied from an integral dietary component to virtually absent all within a 400 km radius (Gil et al., 2010, 2011). Though quinoa,

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squash, and beans are also present, maize is clearly the most abundant and frequent cultivar found in archaeological remains in this region, and its consumption can be measured by stable isotope analysis.

The earliest European descriptions of Central Western Argentina identified two different ethnic groups: the Huarpes, in the northern part of the region and the Puelches in the southern part (Durán, 2000; Michieli, 1983; Prieto, 1997–1998). It is a simplification of the probably more complex ethic panorama (Durán, 2000; Michieli, 1983; Prieto, 1997–1998) but useful for the topic here addressed. The Huarpes were characterized as sedentary farming groups, with a medium population density. The Puelches were characterized as mobile hunter–gatherers with low population density (Michieli, 1983; Prieto, 1997–1998). Given this historical panorama it has been proposed that the South American boundary of farming, primarily (but not exclusively) maize production, is 30–32°S (Gil, 2003; Gil et al., 2006, 2010, 2011; Lagiglia, 2001). This variation in the dietary dependence on maize within a relatively small geographic area provides an ideal place to evaluate the utility of macroecological models designed to explain patterns of subsistence variability at a global scale.

As a first attempt to explain the distribution of prehistoric maize farming in Central Western Argentina, we derive expectations from a model of environmental constraints on hunter–gatherer plant intensification (Johnson and Hard, 2008) and combine these expectations with basic environmental constraints that should partly determine the labor costs of and risk associated with growing maize. The results presented here build upon Binford's (2001) global hunter–gatherer[1] and environmental data sets. We specifically evaluate the proposition that the presence and absence of maize in Central Western Argentina is systematically related to two dimensions of environmental variability [effective temperature (ET) and the availability of aquatic resources (following Johnson and Hard, 2008)] which have been shown to condition different paths of intensification both among contemporary hunter–gatherers (Binford, 2001) and among archaeological sequences (Johnson, 2004, 2008a) and that maize agriculture is also constrained by the season of rainfall. Given the difficulty of measuring prehistoric population density, here we follow Binford's (1983, 2001) logic that the process of intensification is driven by population growth and the subsequent packing of foraging groups on a landscape. To model intensification, we assume that populations grew in the past. This does not mean we expect every place in the world to follow a linear intensification pattern, just that where population densities do grow over time, we expect to see a regular pattern of intensification. Where this is the case, we should be able to predict the different paths that intensification took given three environmental constraints that are associated with modern hunter–gatherer and horticultural subsistence strategies: dependence on fishing, ET, and season of rainfall. While these static models are relatively successful at anticipating the presence and absence of maize cultivation across the archaeological areas examined here, significant opportunities to improve our understanding of subsistence change are highlighted by limitations of the models. Using our hierarchical method the limitations of our general, static models point to and provide a guide for determining the important variables at a regional scale of analysis.

2. Population packing and Intensification

Over the past 20,000 years, at both regional and global scales, the dominant pattern of subsistence change indicated by the archaeological record is that of intensification. With respect to subsistence economies, intensification is generally defined as a process by which more energy is extracted or produced per unit area through a shift in subsistence strategy or technology (Binford, 2001: 221, 357; Boserup, 1965: 43; Brookfield, 1972; Morrison, 1994, 1996; Netting, 1968, 1993: 262). This process describes a pattern of behavior in which groups of people shift their temporal and spatial scale of land use to produce more food from smaller segments of a landscape. Given that intensification appears to be the dominant pattern of subsistence change throughout prehistory and that maize cultivation is one strategy useful for boosting the productivity of a resource patch on a landscape, background knowledge of the important variables that partly determine alternative patterns of intensification is integral for explaining both the prehistoric presence and absence of maize cultivation.

From an ecological perspective, the adoption of domesticated plants by foragers is one outcome of processes that, more generally, drive changes in forager subsistence systems (Binford, 1983; Flannery, 1986). Foragers respond to dynamic changes in their environment. Whether the environmental changes are demographic, social, or physical, the organization of foraging systems fluctuates to control and dampen uncertainties inherent in environmental variation. Binford's (1999, 2001) cross-cultural examination of foraging societies cogently argues that the process of population packing is one demographic factor that dramatically conditions differences in the organization of foraging groups and, under some environmental and demographic scenarios can lead to farming.

Binford (2001:375) has identified a specific value of population density, a hunter–gatherer packing threshold, which marks the population density (about 9 persons/100 sq km) at which there is one minimal group (about 21 people) per foraging area (about 225 sq km) on a landscape meaning that there are no empty foraging areas into which hunter–gatherers can move to exploit fresh resources. At this density, there are pronounced differences in the organization of modern hunter–gatherer subsistence strategies. There are almost no modern hunter–gatherers above this density who are dominantly dependent on hunting terrestrial animals (Binford, 2001:381). At higher values of population density, ethnographically recorded hunter–gatherers are either dominantly dependent on terrestrial plants [primarily where it is warm effective temperature [ET] $\geqslant$ 12.75 °C] or dominantly dependent on aquatic resources [primarily along coasts, rivers and streams (cf. Keeley, 1995)] as shown in Table 7.1.

While the process of intensification must begin before a region becomes packed, once this density is reached, residential mobility options are severely limited (Binford, 2001: 380–387). Thus, many changes in subsistence strategies, related aspects of social organization and settlement, are expected to be density-dependent. As Binford (1999:11) postulates, "Other things being equal, the packing threshold should appear across geographic space at different times depending on the length of time that populations had been increasing in a region and the dynamics responsible for different rates of population growth. One would therefore anticipate culture change to be both chronologically and geographically patterned".

Archaeologically the specific timing of changes in subsistence and social organization are expected to vary based on the relative timing of a region's initial occupation, size of initial populations, rates of population growth, and migration rates. To the extent that these changes are part of a regular intensification process, it should be possible to predict the dates at which they would occur in regions where the date and approximate size of initial occupation are known and rates of population growth could be estimated. It should also be possible to recognize regions that do not follow a regular pattern of intensification.

[1] Binford (2001) organized data on 339 ethnographically documented hunter–gatherers from diverse environmental settings around the world for use as a frame of reference for archaeological research.