Living outside the box: An updated perspective on diet breadth and sexual division of labor in the Prearchaic Great Basin

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A B S T R A C T

A tremendous amount has been learned about the Prearchaic (before 9000 BP) Great Basin since we advocated a perspective of sexual division of labor based on Human Behavioral Ecology a decade ago. Many investigators have taken our advice and a few have challenged our assumptions and inferences. One of the most substantive critiques has been that we misunderstood the paleoenvironmental parameters of ungulate populations during the Pleistocene Holocene Transition (PHT). Simultaneously, behavioral ecologists have advanced our understanding of sexual division of labor among modern foragers, but these studies appear to have gone unnoticed by Great Basin prehistorians. We review findings of the last ten years and suggest that the key to understanding patterning in the PHT still relies on understanding (a) variability in men’s and women’s foraging goals and the resulting division of labor; (b) the abundance and distribution of large prey, (c) how changing environmental parameters affect both the division of labor and the distribution of resources, and (d) the relative influence of search and handling costs on residence time in PHT wetlands. We suggest that consideration of how paleoenvironmental variability structured sexual division of labor remains key to fully understanding Prearchaic lifeways in the Great Basin.

1. Introduction

Over ten years ago, Elston and Zeanah (2002) offered an explanation for the seemingly contradictory combination of traits observed in Great Basin archaeological sites dating to the Pleistocene–Holocene Transition (PHT): evidence for high mobility, lithic technology adapted to hunting, and faunal assemblages suggesting broad spectrum foraging. The paper compared applications of various behavioral ecological models (Simms, 1987; Raven and Elston, 1989; Zeanah et al., 1995; Pinson, 1999), using the simulated resource structure of Railroad Valley, Nevada (Zeanah et al., 1999) for the early and middle Holocene. Drawing from ethnographic studies of diet and patch choice, we proposed that the observed patterns of site location, abundance and content resulted from the different foraging goals and strategies of men and women in the environmental context of the PHT Great Basin. This Prearchaic pattern differed fundamentally from subsequent Archaic (post 9000 BP) lifeways.

Responses were mostly favorable, although there were some misinterpretations of the piece. Here we clarify the model by updating the original framework with new insights from human behavioral ecology (HBE) and a better understanding of the availability of large prey (artiodactyls). Specifically, we highlight that (1) the key to understanding patterning in the PHT still hinges on understanding variability in men’s and women’s foraging goals and the resulting division of labor; (2) while some suggest that large prey were too uncommon to have been crucial resources for Prearchaic Great Basin foragers, the concentration of artiodactyls around wetlands actually made hunting large game predictable and reliable as long as foragers were free to move from one wetland basin to another; (3) understanding both the division of labor and the patchiness of large prey provides a clear framework for framing PHT foraging, diminishing returns and how these effects forager mobility and site formation patterns.

Before detailing our model of PHT (Prearchaic) lifeways, we first review insights from 2002 and compare how they stand up to additional findings over the last 10 years.

1.1. The PHT record: key observations

Elston and Zeanah (2002) made a series of key empirical observations, most of which have held up to subsequent
investigations. However, recent work adds some important nuances. We highlight the original thinking in 2002, and update it with new evidence.

1. Most Prearchaic assemblages occur in lowland locations near the wetlands that occupied numerous Great Basin valleys during the PHT (Fig. 1). Despite evidence for limited habitation levels elsewhere (Basgall, 2005; Middleton et al., 2014), this continues to largely be true.

2. These assemblages typically lack diversity and evidence of prolonged habitation, storage, or refuse accumulations (Beck and Jones, 2009). While we agree that taphonomic factors operating on many PHT surface sites may have obscured evidence for residential and storage features, we argue that this is due to the essentially ephemeral nature or absence of such features in short term camps used by highly mobile people (Binford, 1980). Substantial features for long term habitation such as pithouses, prepared hearths, and large, deep storage pits would likely be preserved to some degree even if subjected to bioturbation and inflation (upward movement of clasts). We observe that PHT age deposits are often well enough protected in Great Basin caves and rockshelters which buffer taphonomic loss (Surovell et al., 2009) preserving organic artifacts and textiles, but evidence from these deposits, invariably thin and containing only simple hearths, does not support extended occupation (Kirner et al., 1997). While such sites often contain caches of tools, or textiles that would have been useful to mobile groups cycling between wetlands, caches of food are absent. Variability in duration of occupations within particular wetlands is evident in the use of local toolstones, the extent to which tools of non local materials were curated and recycled, and possibly, the kind of tools manufactured (Duke and Young, 2007; Smith, 2007; Beck and Jones, 2009; Smith, 2011). This may relate to the abundance of wetlands and distance from one wetland to another.

3. Further investigations have sharpened the distinctions between PHT and Archaic use of seeds. Most importantly, Prearchaic use of ground stone milling tools is episodic to altogether absent. While there is strong evidence that PHT foragers used seeds at least occasionally, they appear to have usually done so without the accouterments of milling technology that are “hallmarks” (Jennings, 1957) of the later Archaic lifestyle (Basgall, 2008; Beck and Jones, 2009: 143; Goebel et al., 2011; Madsen, 2007; Rhode et al., 2006; Rhode and Louderback, 2007; Schmitt et al., 2007; Yoder et al., 2010).

4. Tools suggestive of large game hunting and processing dominate Prearchaic chipped stone assemblages. This has largely remained true even though evidence has mounted that stemmed points were designed for use in a variety of tasks (Beck and Jones,
20209). However recent use wear analyses suggest that functions included use as projectiles for hunting and butchering knives (Duke, 2011; Lafayette and Smith, 2012). Multi functionality should have resulted in increased flexibility and toolstone con servation, both beneficial for highly mobile adaptations.

5. Diverse toolstone sources in Prearchaic assemblages suggest sub stantially larger lithic procurement zones for Prearchaic foragers than typical of later Archaic foragers. Toolstone source profiles continue to show that catchments exploited by PHT foragers, while likely not so large and probably much more variable than envisioned 10 years ago, were substantially larger than their Archaic successors (Duke and Young, 2007; Smith, 2007, 2010, 2011; Duke, 2011; Goebel et al., 2011; Smith and Kielhofer, 2011; Jones et al., 2012). It seems most likely that toolstone was acquired directly by residential mobility, and to a lesser degree, by trade. Although we do not deny the possibility of logistic procurement, we see little evidence for it in the form either of upland base camps or in the use of upland toolstone quarries. Exploitation of such large territories suggests higher mobility, lower human population densities, and lower levels of competition for resources than prevailed in the Archaic.

6. Available faunal evidence indicates that Prearchaic foragers hunted a broad array of prey similar to that of later Archaic foragers. Recently analyzed faunal assemblages have continued to demonstrate use of the large artiodactyls present in the Great Basin today, as well as a variety of smaller game (Hockett, 2007; Pinson, 2007; Goebel et al., 2011; Janetski et al., 2012). However, lack of evidence for bone boiling or marrow processing, commonly evident in Archaic archaeological assemblages, sug gests that Prearchaic foragers did not usually process fauna as intensively as Archaic foragers.

These six key points paint a concise picture of Prearchaic for agers as targeting wetlands, utilizing diverse toolstone sources, having low population densities, exploiting large territories, doing much the same sorts of things site to site, not using substantial residential structures, moving residential sites too frequently for midden to accumulate, lacking storage or extensive seed processing equipment, relying on flaked stone tools that while multifunctional, suggest a focus on large game hunting and processing, and exploiting diverse flora and fauna, including low ranked resources.

And yet, the same empirical conundrum exists today as it did in 2002: PHT foragers seemingly targeted large game while simul taneously exploiting diverse, low ranked resources, all the while appearing to maintain high residential mobility. As in 2002, we suggest the first key to understanding this problem is to understand the organization of men’s and women’s subsistence labor.

2. Sexual division of labor

In 2002, Elston and Zeanah benefited from a growing body of HBE studies on the socioecological context of sexual division of labor among modern foragers. We drew from the summaries of Hawkes (1990, 1996) and Bleige Bird (1999), and explicitly used the behavior of contemporary Hadza foragers (O’Connell et al., 1988; Hawkes et al., 1991) — modern big game hunters par excellence — as an analogy for how Great Basin foragers employed sexual divi sion of labor to balance a “risk prone” hunting strategy with a “risk averse” gathering strategy. In our view, the paleoenvironmental structure of the PHT did not impose the same spatial conflicts be tween men’s and women’s foraging opportunities faced by foragers later in the Archaic (post 9000 BP). Prearchaic men and women found their best foraging returns in and near wetland patches producing an archaeological record that appeared highly mobile and hunting oriented, yet broad spectrum. We specifically assumed that Prearchaic sexual division of labor was organized in essentially the same manner as it was for ethnographic Great Basin foragers (Elston and Zeanah, 2002: 122–123, cf. Zeanah, 2004).

Since 2002, HBE research on sexual division of labor among hunter—gatherers has advanced significantly allowing a more so phisticated understanding of its causes and variability. Data from a small but diverse and extensively studied group of contemporary foraging societies affirms that the critical differences between men’s and women’s prey concerns both the variability and mean of expected return. Women tend to select prey that can be reliably captured and used to provision children. In contrast, men generally target high yield resources that are amenable for distribution among larger social groups, but vulnerable to risks of failed pursuits and encounters. Debates in HBE over the last several decades have often reduced the issue to hunting for food vs. hunting for prestige (Marlowe, 2007; Gurven and Hill, 2009). Are men costly signaling by funding a “public good” with resources risky to acquire? Can such “risky pursuits” ever offer a reliable means of provisioning offspring?

In a recent paper, Codding et al. (2011; Codding, 2012) point out that hunting for prestige vs. food is a false dichotomy. Both may occur, but emphasis on one or the other will vary, even on a day to day basis within the same society, depending on the structure of the resource base. Specifically, Codding and colleagues demon strate that the reliability of high energy resource (e.g., large game) acquisition, determines the extent of conflicts between the goals of maximizing energy and minimizing risk, which in turn predicts the degree to which men’s and women’s foraging efforts diverge or converge.

Men’s and women’s foraging goals differ: men most frequently maximize energy without much attention to risk, and women attempt to minimize risk over any preference for energy. When high energy resources can be acquired with low risk of failure, men’s and women’s foraging strategies tend to converge on similar resources. Convergent foraging strategies are of two kinds depending on the amount of alloparental support available. Where larger groups provide more alloparents, women and men both target high energy resources (e.g., Agta; Goodman et al., 1985). When groups are small and there are fewer alternative caregivers, men’s direct and reliable acquisition of large game is made possible by women’s logistical support — not in the Binfordian sense (Binford, 1980), but in terms of supporting residential moves (e.g., Ache: Hawkes et al., 1982, 1987) or in processing (e.g., Inuit: Jarvenpa and Brumbach, 2006).

When large, high energy resources decline in abundance and success becomes uncertain, foragers trade off minimizing risk and maximizing energy in compensation, and foraging strategies diverge by gender. Men are more likely to target high risk, high energy resources that can infrequently provision all within the group, while women focus on low energy resources to reliably provision offspring and consequently provide the bulk of the food sources consumed by the foraging group (e.g., Martu, Meriam during turtle hunting season: Codding et al., 2011; Hadza: Marlowe, 2010; Ju/’hoansi during dry season: Lee, 1979; and virtually all ethnographic Great Basin foragers: Steward, 1938).

The main insight is that whether a group’s division of labor is more likely to converge or diverge depends on the reliability of high energy resource acquisition. In the Great Basin, that likely depended most on the reliability of hunting large prey (Fig. 2). If our assessment of the resource structure of the PHT Great Basin (discussed below) is correct, we believe that hunting success for higher ranked prey, especially ungulates, was actually quite high because they were reliably intercepted in and near the wetlands that occupied most Great Basin valleys, and there was relatively little competition for these resources because of the low human
population density. Consequently, sexual division of labor among Prearchaic hunter-gatherers was more convergent than it was for later Archaic foragers. Ted Goebel et al. (2011:498) were not far off the mark when they commented that the mortuary associations of the Buhl burial suggested a lower degree of sexual division of labor than we inferred in 2002. Admittedly this is a single example, but provocative nonetheless.

Given the broad array of small to large sized game represented in PHT faunal assemblages, we can accommodate either the possibility that Prearchaic women regularly contributed to the diet by pursuing a similar array of prey as men (like Agta women; Goodman et al., 1983), or Prearchaic men contributed the bulk of the diet through hunting while women either focused on processing (like many Arctic groups, e.g., Jarvenpa and Brumbach, 2006) or played a more logistical role in facilitating hunting (like Ache, e.g., Hawkes et al., 1982). However, we suspect that alloparenting opportunities were limited in the small groups that seem typical of the PHT Great Basin and, much like contemporary Ache, Prearchaic women supported the high residential mobility necessary to maintain high encounter rates with large game. The Ache case provides a particularly instructive analogy here: while Ache women do often forage for lower ranked, reliable resources, they regularly bypass these opportunities in order to facilitate men’s hunting of larger, reliably encountered, and widely shared resources (Hawkes et al., 1982). This is precisely the circumstance we pose for the Prearchaic, accounting for the signatures of high mobility, hunting oriented technology, and broad diet. Whether or not this is true, however, hinges on understanding the abundance of large prey during the PHT – something that has been the topic of recent debate.

2.1. Abundance of large game

Broughton et al. (2008), Hockett (2007), and Pinson (2007) have critiqued the inference that large game (Artiodactyla) played an important role in Prearchaic subsistence strategies. All three point to the low proportion of large ungulates relative to smaller game at PHT sites with preserved faunal assemblages. Leaving aside the question of how many rabbits, squirrels, or grasshoppers it takes to equal the caloric return of one deer, we point out that artiodactyl remains are frequently more abundant in PHT components (both in MNI and NISP) than in later Archaic deposits (cf. Pinson, 2007: Table 10.4; Hockett, 2007: Table 11.2). Relative to the entire faunal assemblages from multicompontent sites with PHT deposits, it is the abundance of small game, not the rarity of large, that accounts for the relatively low ratios of ungulates in Prearchaic components (as would be expected with a converging diverging division of labor, see below). Further, we argue that these relatively low artiodactyl indices could be due to field processing thresholds, or sampling biases reflecting profoundly different PHT and Holocene site formation processes. Until these factors are understood and controlled for both small and large fauna, simple appeals to artiodactyl indices alone are inconclusive, and we argue that the only conclusive inference that can be made is that both large and small prey were important prey items of PHT foragers, precisely the phenomenon that calls for explanation.

More profoundly, Broughton et al. (2008) have challenged our interpretation of paleoclimatic evidence that cool, moist climatic conditions of the PHT were capable of supporting sufficient carrying capacities for large ungulates near wetland patches to make hunting them profitable. Based on climatic reconstructions they argue that artiodactyl densities were too low during the PHT to have served as reliable resources, because orbital forcing resulted in greater seasonality during the PHT. Longer, hotter summers and more severe winters limited artiodactyl carrying capacities in the Great Basin until seasonality ameliorated in the late Holocene. We share Don Grayson’s (2011) skepticism that paleoenvironmental evidence supports PHT seasonality of the scale that Broughton and colleagues envisage. However, we point out that if these reconstructions are accurate, artiodactyls should have, nonetheless, been even more concentrated around marshes and lakes.

Present use of wetlands and riparian zones by large mammals is well documented. Elk and mule deer use palustrian habitats for shelter and foraging (Lohman, 2004). Several studies describe deer and elk use of riparian habitat (Gamonley, 2004) for water, food, and thermal cover for resting and birthing especially in summer when uplands dry out (Leckebendy et al., 1982; Marcum and Scott, 1985; Raedeke et al., 1988; Walmo, 1981; Wittmer and Calaste, 1983). Riparian zones are preferred corridors for deer movement, especially between uplands and valley floors. The marshes and riparian zones of the Malheur Lake/Blitzen River/Silvies River system are home to a large, permanently resident mule deer population, where females often wade out to Malheur Lake islands to give birth (Fig. 3).

Anecdotal evidence of use of wetlands from wildlife refuge managers at Stillwater, Ruby Lake, and Malheur indicate that antelope and bighorn sheep also make use of wetlands. Antelope water and forage along the margins of the Malheur and Stillwater marshes in places where sight lines are undiminished by trees or high brush; around A.D. 1300, antelope were apparently driven into the marsh and processed at the Sheepy East 1 site in Lower Klamath Lake (McGague, 1985). Bighorn sheep come down to wetlands where there is nearby escape terrain (e.g., to Stillwater Marsh from the Stillwater Mountains via Stillwater point and from the Ruby Mountains down to Ruby Lake).

While Broughton et al. (2008) argue that greater seasonality with harsher winters and hotter summers would have degraded critical artiodactyl habitat, forage, and water sources, this should have made large game more dependent on wetland habitats, very likely concentrating animals in and adjacent to the marshes and
riparian zones feeding them, particularly as climate grew dryer and marshes diminished.

In 2002, Elston and Zeana were unaware of the extent of artiodactyl use of wetlands and proposed that large animals would have been hunted from lowland bases in low to mid elevation brushy steppe. In many of the narrower Great Basin Valleys, this would have entailed foraging trips of less than 10 km, and not required (contra Madsen, 2007) extensive logistical trips outside the valley. If however, we are correct to assume the presence of artiodactyls in and immediately adjacent to wetlands, then Prearchaic hunters could have procured them without incurring as high search and transport costs as those paid by Archaic hunters. Human foragers knew where and when animals would most likely be located, whether they were resident in a wetland, moving in and out of it, or visiting its margins. All of these situations could be taken advantage of through encounter or intercept hunting strategies.

Indeed, if seasonal artiodactyl migration routes circulated through PHT wetlands, Prearchaic hunters could have practiced intercept hunting strategies to a much higher degree than their Archaic counterparts. Compared to Middle/Late Holocene Archaic foragers, PHT Prearchaic foragers do not appear to have processed artiodactyl remains as intensively—there is no evidence for bone boiling or marrow processing as seen during the Archaic. All this suggests that success rates with artiodactyls were higher in the PHT, allowing foragers to avoid excessive bone transport to, or processing at, the central place. We find support for the importance of intercept hunting of large game in the distribution of sites in Railroad Valley Nevada (Fig. 4). The figure illustrates the distribution of PHT sites and isolates in the region relative to a paleoenvironmental model showing the maximum extent of Pleistocene wetlands and surrounding landforms. The Paleoenvironmental model was constructed by combining two independent analyses of the original Railroad Valley Model (Zeanah et al., 1999). We estimated the minimum and maximum extent of Pleistocene wetlands from modern soil map units that we reasoned were likely to have formed at the bottom and margins of lakes (although they include some eolian soils that clearly postdate Pleistocene wetlands). The zone of minimum extent is the modern ahbic playa and adjacent saline soils that support very alkaline vegetation communities. The high salinity of these soils likely results from the desiccation of shallow lakes and marshes. The riparian soils are simply modern riparian soil map units. The zone of maximum extent is based on soil map units currently classified as irregularly inundated, under the assumption that these were most likely flooded during Pleistocene highstands. This overlays a layer of geomorphic landforms delineated by analysis of air photo stereo pairs. Those landforms representing relict Pleistocene shorelines and lagoons, and fluvial gravel bars are highlighted so they show through the wetland layer. The close correspondence of the pluvial/fluvial landforms with the wetland zone derived from soil map units reassures us that we have derived a reasonable approximation of the extent of Pleistocene wetlands. Young fans are alluvial surfaces that are probably too young to bear in situ PHT sites and isolates. Old fan and upland landforms are old enough to contain PHT cultural materials.

To determine if there are significant differences in PHT versus Archaic site clustering along these different landforms, we ran a series of point pattern analyses using Ripley’s K. Ripley’s K calculates the distances between neighboring points at specified spatial extents and determines if the average distance between neighbors in a sample differs significantly from a theoretical randomly homogenous distribution. Here, K[t/o] reports the ratio of the theoretical or random K value over the observed K value. Potential values range from 0 to 2 with values close to zero suggesting significant clustering, values close to 1 suggest a random distribution, and values close to 2 suggest significant dispersion. These values report clustering at a 1 km radius within the valley, asking whether or not sites are more or less likely to have a local neighbor than would be expected by random chance. Significant departures of an observed value from a theoretical value are based on a Monte Carlo simulation with 10,000 iterations. Multi scalar Ripley’s K increases the neighborhood size across multiple extents to a maximum radius.

An analysis of local spatial clustering reveals that PHT sites are significantly clustered (K[t/o] 0.05, p < 0.0001) while Middle Holocene sites exhibit only marginally significant local clustering (K [t/o] 0.33, p 0.0678). This suggests that neighboring PHT sites are closer to one another than would be expected by random chance. Extending this to a multi scale cluster analysis calculating Ripley’s K at increasing distances across the valley shows that PHT sites are significantly clustered throughout almost the entire extent of the valley (Fig. 5; Pelissier and Goreaud, 2010; R, 2014). In contrast, Middle Holocene sites only reveal significant clustering at scales up to half of the valley, showing essentially a random distribution across half of the extent.

These findings imply that PHT sites were more narrowly focused on particular habitats within the valley. The strongest clustering of PHT sites and isolates is along ancient fluvial gravel bars of the creek flowing into the basin from the north (Zancanella, 1984). A weaker, but suggestive clustering of sites is apparent near the drainage flowing from the south. Such locations likely would have been suitable for intercept hunting of large game using the riparian zones as migration corridors from surrounding uplands. The largest known PHT site in the region (Elston et al., 1979), an extensive lithic scatter, is highlighted as a likely location of a central place base camp by encircling it within a 10 km foraging catchment. Situated on a relict pluvial gravel spit extending far out into the wetland to intercept the stream feeding the basin, the site provided an elevated dry place ideally situated to access the stream and the surrounding wetlands and lake to the south. Moreover, it is also conveniently located for hunters intercepting game along the riparian corridor to the north. Similar PHT site concentrations along riparian corridors have been observed elsewhere in the Great Basin (Mullins et al., 2013; Duke and King, 2014; Madsen et al., 2015). We suggest that this is the sort of site locational strategy that would have occurred under conditions of converging and diverging division of labor.
The crucial point is that the patchy concentration of artiodactyls around marshes and lakes made their acquisition there reliable; their overall abundance is less important, especially given that with low human population densities and small group size, PHT foragers would have been free to travel to new wetland patches as local hunting returns diminished. The large animals in and adjacent to wetlands would have constituted low hanging fruit for Prearchaic foragers. However, their local populations should have been relatively easily depressed by hunting, particularly given the resource structure envisioned by Broughton and colleagues. This would have had some interesting implications for the patch preferences of Prearchaic foragers.

2.2. Diminishing returns, marginal value and mobility

As illustrated by the Marginal Value Theorem (MVT) the duration a forager should stay within a patch can be modeled by the marginal value of a diminishing returns curve (Charnov, 1974; Charnov and Orians, 1973; Charnov et al., 1976). The shape and height of the curve depends on the quantity of resources being exploited and the rate at which foragers can depress foraging returns within a patch. The length of time foragers stay within a patch before departing for another depends on the time it takes to travel to an adjacent patch (Fig. 6). The classic formulation of the MVT did not distinguish search and handling time, but Bettinger...
and Grote (2012) have recently shown that the contribution of handling time can also have a significant effect on the rate of diminishing returns and patch residence time. Fig. 6 shows diminishing returns in two patches we use to illustrate two alternate foraging activities feasible in the same patch, such as the catchment illustrated in Fig. 4: artiodactyl hunting and broad based foraging.

This framework provides an important key to understanding PHT mobility. On moving into a new wetland patch, Preparcaic foraging groups targeted the highest yield resources that they could reliably procure, and as we have argued above, this likely involved the foraging strategies of men and women converging on artiodactyl acquisition, resources requiring a high proportion of search relative to handling costs to acquire (Fig. 6, curve a). Easily encountered ungulates would have been relatively quickly depleted, and the length of stay in a particular location would have depended on the distance to the next hunting location. However, the decision of when to leave would have depended on women who had the option of either staying where they were and diverging their foraging to reliably acquire other, lower ranking resources requiring higher contributions of handling costs (Fig. 6, curve b), or moving to a new location where they could continue to help men reliably pursue higher ranked prey. For travel times less than (1), women do best by traveling with men to the next wetland hunting patch, without diverging their labor. For travel times greater than (1), women do better by staying put and harvesting lower ranked, but still dependable, resources. As large game encounter rates fell, we expect that men would continue pursuing large ungulates — the resources most amenable to social provisioning — with diminishing chance of success. Men may have been forced to shift from an intercept strategy in which encounters could be predicted based on animals consistent movements (see O’Connell et al., 1988; see also Lee, 1968), to an encounter strategy in which success was less reliable. Women may have responded to episodic opportunities for resources with post encounter return rates near large game (cattail pollen, duck eggs, grasshopper/cricket window) that would encourage sticking around longer, but overall, this pattern should hold.

Thus sexual division of labor would have diverged, as women switched to broad based foraging and men continued to hunt large game, but only until reaching the travel threshold of broad based foraging (ii). Under the PHT conditions we envision where hunting patches were tied to the distribution of wetlands, the abundance and size of wetlands would always have restricted to the degree to which sexual division of labor diverged. In larger wetland systems, the next hunting location would often have been quite near. Even if all feasible hunting patches were depressed, the abundance of wetlands always kept travel costs to the next basin comparatively low, encouraging regular moves between basins.

This model accounts for current evidence that, from time to time, particularly in relatively isolated wetlands where the costs of traveling to the next wetland basin were relatively high, Preparcaic foragers stayed in a patch long enough for their division of labor to diverge, with women beginning to exploit some lower ranked, higher handling cost, but more reliable resources, but they rarely stayed in one basin long enough for women to invest in seed milling technology. The resulting archaeological residue gives the appearance of a diverse foraging strategy, but one that is actually a palimpsest of diminishing returns in a relatively finite environment.

This contrasts with the scenario Madsen (2007) poses that the size of a particular wetland patch and abundance of resources targeted by women determined the length of residence within it while men foraged logistically from wetland bases in a strongly divergent sexual division of labor; a proposal that ignores both factors inherent in the marginal value theorem: travel time between patches and the marginal return rate of patches (cf. Charnov et al., 1976), as well as whether in patch costs are relatively high in search or handling time (Bettinger and Grote, 2012). We suggest that Madsen is correct in assuming that larger wetlands should have been occupied longer, *ceteris paribus*, since larger wetlands probably attracted larger ungulate populations and offered more locations suitable for intercept hunting than smaller ones. However, the sexual division of labor of Preparcaic foragers residing in larger wetlands should have been resistant to divergence given the short time required to travel to the next available hunting patch. Even if they depressed ungulate abundance in an entire large wetland, they still would have had the option to move to another wetland to hunt, which during the PHT would have been relatively nearby.

We argue that the six well demonstrated features of the PHT archaeological record discussed previously are ample evidence that Preparcaic foragers targeted resources that required relatively low proportions of handling to search costs, not the high handling cost resources that were characteristic of the foraging strategies of ethnographic women in the Great Basin (Steward, 1938; Simms, 1987). Thus in patch residence times should have been generally short, and the prolonging effects of wetland size on patch residence time relatively minor for Preparcaic foragers. The key archaeological signature of this is the well documented rarity of ground stone milling equipment in the Preparcaic archaeological record. It is
clear that regardless of either wetland size or distance between wetlands, Prearchaic foragers rarely stayed in one basin long enough for women to invest in seed milling technology. This argues strongly that gendered allocations of subsistence labor must have been generally convergent, and Madsen is incorrect to pose a strongly divergent sexual division of labor in larger PHT wetlands.

Larger game around wetlands would have been more vulnerable to resource depression, although larger wetlands should have been more productive and harder to depress than smaller basins. Nevertheless, foragers would have only lingered in a wetland patch that was much more productive in high energy resources compared to other wetlands (Elston et al., 2011). If wetland size alone significantly affected residential mobility, one would expect to find evidence of reduced mobility in climatic intervals, such as the Younger Dryas (YD), when wetlands were most extensive. So far, this is not the case. Thus, we suggest the critical factor affecting the length of stay in PHT wetland basins should have been the distance to the next basin, not the size of the local wetland.

This scenario is relevant to the archaeological record of the distal Old River Bed (ORB) region in the Bonneville Basin studied by Daron Duke (2011; Duke and Young, 2007). The stream channels in the ORB originated in the Sevier Basin and flowed northward into the southern Bonneville Basin in a low gradient delta. The resulting large ORB wetland was occupied and exploited by Prearchaic foragers between 12,000–9300 cal BP who left large numbers of archaeological sites marked by lithic assemblages (Duke, 2011). These mostly surface sites are dated by associated paleo stream channels, and fall into two spatial and chronological groups: a western one (Wild Isle Dunes) between 11,500–10,480 cal BP immediately after the cool, moist Younger Dryas interval, and an eastern one (Wildcat Dunes) between 11,200 and 9300 cal BP. Here we adjust Duke’s calibrated dates to reflect subsequent information (Madsen personal communication). After the Younger Dryas, the ORB delta wetland was well supplied by ground water and grew in size, but there after became increasingly desiccated until it disappeared by about 9300 cal BP.

Archaeological assemblages found along the earlier channels of the western subarea suggest relatively brief stays, and lithic artifactual facts optimized for transport efficiency; exotic toolstone is common, suggesting long distance moves between basins. These assemblages coincide with the late cool mesic Younger Dryas climatic interval when lakes and wetlands were common throughout the Great Basin (Goebel et al., 2011), and average distances between wetlands were relatively short. In contrast, assemblages from the later eastern subarea coincide with a time when the ORB wetland reached its maximum extent (fed by ground water), but paradoxically, also coincide with the post Younger Dryas progressively dryer climate in which wetlands outside the ORB declined and most eventually disappeared, resulting in continually increasing distance between surviving wetlands. As expected, the eastern lithic assemblages represent longer stays and less transport efficiency, and but contain similar proportions of exotic toolstone, suggesting that later foragers maintained their access to distant toolstone sources.

Thus it appears that when Great Basin wetlands were extensive, forager stays in the distal ORB were relatively short before moving to an adjacent wetland basin; exotic toolstones suggest people regularly visited several basins in a large region. Later, when most other valley wetlands were also drying or completely gone, people stayed longer in the ORB. And yet, despite the more prolonged residential stays of Prearchaic foragers, resource depression, “never reached the point (requiring) intensive seed processing” (Duke, 2011:239).

3. Discussion

As did its 2002 predecessor, this paper stems from an attempt to explain a seemingly paradoxical record: a foraging population that seems technologically geared for large game procurement, but one that simultaneously exploited a diverse set of lower ranked resources requiring higher handling costs, while men continue to pursue large game at lower rates of return, likely achieved through logistic mobility.
resources while appearing to have employed extremely high residential mobility encompassing expansive lithic conveyance zones. Those who argue that large game played only a minor role in Prearchaic subsistence settlement strategies address the exploitation of such large territories unconvincedly if not at all. What accounts for the scale of catchments evident in lithic toolstone profiles if not high mobility and hunting? If Prearchaic foragers were focused on an array of wetland resources comparable to that exploited by Archaic and ethnographic foragers, there should have been little need to leave one wetland for another because wetlands would have been resistant to human induced resource depression (Zeana, 2004). If resources became scarce within the daily foraging range, Prearchaic foragers should simply have residentially moved to the next patch in the same wetland as Bob Kelly (1995) modeled for Archaic foragers. Seasonal and interannual fluctuations in wetland productivity should have been countered in the same manner as Archaic foragers: settling within the most productive wetlands, milling and storing seeds to deal with risk, and acquiring toolstone mostly by logistical procurement. If all this were true, Prearchaic and Archaic sites and settlement patterns would be essentially identical — but they are not. Toolstone acquisition embedded in a residentially mobile pattern geared to large game acquisition continues to be the only viable explanation posed for the Prearchaic pattern that is supported by ethnographically documented causes of hunter—gatherer mobility (cf. Binford, 2001; Kelly, 2013).

We argue that understanding the Prearchaic pattern requires a detailed grasp of the sexual division of labor and how it interacted dynamically with variability in the abundance of high ranking resources (mainly artiodactyls) and their patchy distribution in the PHT Great Basin. We suggest that Prearchaic foragers targeted wetlands in discrete basins where large game were likely to be abundant and reliably encountered. When encounter rates with large game declined, women shifted focus to smaller more reliable resources, but only until a point at which they were better off traveling with men to the nearest adjacent wetland in order to again target higher ranking artiodactyls.

Of course, this system was dependent on the lakes and wetlands in Great Basin valleys fostered by the relatively cool moist climate of the PHT. These formed homogeneous patches containing essentially inexhaustible plants, birds, and small animals, along with large game, which we argue would have been tethered to wetlands. It is likely that the productivity of wetlands, particularly as large ungulate patches, would have been vulnerable to climate change. Recent dates from Paisley Caves (Jenkins et al., 2012), extend the Prearchaic back from the early Holocene into the Bolling-Allerød, about the time lakes Bonneville and Lahontan were regressing from major highstands (Grayson, 2011). Although dramatic climatic variability over this span of over six millennia (Fig. 6) would have affected the productivity of wetland patches and the large game they fostered, all wetland patches would have been similarly so affected, and wetlands remained fairly abundant in the Great Basin. For example, even though paleo-environmental evidence suggests that the Bolling-Allerød in the Great Basin was relatively warm compared to the last glacial maximum (Fig. 7), it was nonetheless cooler than the Holocene, and resulting low evaporation would have helped maintain wetlands in basins even when lakes regressed.

An implication of this extended chronology is that the Prearchaic archaeological record, spread out over a longer period, is even thinner than we realized, providing further support for low population and high residential mobility. However, the consistency of site location, content, and the basic lithic tool kit through this period suggests that Prearchaic foraging strategies were resilient to such climatically induced volatility. Prearchaic technology exemplified by artifacts of the Western Stemmed Point Tradition (WSP) likely served an array of functions, including atlatl dart points, thrusting spear tips, knives and scrapers (Lafayette and Smith, 2012) that allowed Prearchaic foragers to cope with a wide range of climatic variability. This technology represents an overall flexible adaptation perhaps similar to other stemmed traditions in California (Stevens and Coddington, 2009; Stevens, 2012). The morphological variability among stemmed points of the WSP is poorly understood, but could reflect another facet of flexible adaptation, if not technological change through time.

With convergent foraging strategies, frequent residential moves, and a flexible, hunting oriented technology, Prearchaic foragers were able to maintain the same adaptive strategy over six millennia of climate change. The persistence of expansive wetlands throughout this period of variability was the key factor causing the resilience of the Prearchaic adaptive pattern. The patch choice implications of this are that 1) travel time between wetland patches would have remained, if not constant, stable within limits, 2) climatic variability would have altered wetland size and prey density within wetlands, and 3) convergent gendered foraging behavior kept foraging strategies focused on resources requiring low contributions of handling time relative to search time. Bettinger and Grote (2012) show that under these circumstances, both residence time in patches and the proportion of patch resources used should have changed relatively little regardless of whether patch

![Fig. 7. Duration of Western Stemmed Point Tradition plotted with climatological patterns showing that the adaptation existed over substantial environmental variability. Prearchaic technology exemplified by artifacts of the Western Stemmed Point Tradition (WSP) likely served an array of functions, including atlatl dart points, thrusting spear tips, knives and scrapers (Lafayette and Smith, 2012) that allowed Prearchaic foragers to cope with a wide range of climatic variability. This resilience is consistent with predictions of the marginal value theorem, so long as pluvial wetlands persisted.](image-url)
productivity was low or high. Thus, patch choice predicts that Prearchaic foraging strategies should have been resilient to the paleoclimatic variability of the PHT irrespective of how that variability affected wetland productivity.

The success of the Prearchaic lifeway was also predicated on low human population levels and lack of competition for the high ranking resources in wetland sweet spots. Lack of competition for resources made convergent division of labor and high residential mobility productive tactics. Low population levels during the PHT were probably maintained by extreme climatic variability that contributed to infant and child mortality operating as a damper on population in a stable limit cycle (Belovsky, 1988; Winterhalder et al., 1988; Elston et al., 2011).

It appears that the long term success of the Prearchaic lay in the homogeneity of wetland patches and connectedness of the groups exploiting them. Everyone did the same kinds of things in the same kinds of places and apparently, groups were not isolated enough to develop behaviors that caused significant variation in technology. Complex systems with these features can be resilient and highly resistant to change until some critical threshold (“tipping point”) is reached and the whole system shifts to another mode (Scheffer et al., 2012) or fails altogether. Signs that a system is stressed may appear before the critical threshold in the form of short term stochastic changes (“flickering,” Scheffer et al., 2012) to or toward the new mode. Elston et al. (2011) proposed that something like this could account for the episodic appearance of ground stone tools and pottery in late Pleistocene northern China, and we suggest that this could account as well for the infrequent and short term appearance of ground stone in the Prearchaic Great Basin.

Duke’s (2011) analysis of the latest ORB lithic assemblages demonstrates a technological response to environmental change, but not one that transformed the entire system. Adjustments in lithic procurement, production and tool maintenance were made post YD, but the basic tool kit and its functions remained the same until the entire system failed. Duke was able to observe this in the ORB because dating paleochannels in the ORB delta allowed early and later surface sites to be sorted out. Although we might expect a similar technological response in warmer, dryer pre YD climate intervals, nothing like it has so far been observed. It is unclear whether the systemic changes Duke recognizes in the latest ORB lithic assemblages constitute a technological flicker toward a new mode, or a more gradual transition typical of heterogeneous systems with low levels of connectivity (Scheffer et al., 2012).

It was not until wetlands began to dry out in the latter part of the Early Holocene that the Prearchaic adaptive strategy reached a tipping point. As wetlands disappeared, travel time between those that remained would have increased necessitating longer stays in the wetland patches that remained (Charnov, 1974). While we disagree with Broughton and colleagues assessment of the carrying capacity for ungulates of PHT environments, we accept that, as wetlands disappeared, the Middle Holocene Great Basin would have become a poorer place to reliably find large game. As successful encounters with large game declined, distance between patches increased, and the more equable climate released the dampening effect on human population, the sexual division of labor diverged permanently, and women began to procure lower yield, but reliably procured resources like seeds. Handling time would have contributed an increasingly high component of women’s foraging cost in patches further prolonging optimal time in patch for women. We suggest that it is at this point that small seeds regularly entered women’s prey breadth making investment in grinding technology worthwhile (cf. Ugan et al., 2000; Bettinger et al., 2006). In contrast, men would have continued to search for increasingly unreliably encountered, but high yield artiodactyls in patches spatially discrete from women’s foraging locales. Men could only accommodate this conflict with greater logistic mobility. Thus the disappearance of wetlands was a critical factor in the transition from Prearchaic to Archaic subsistence systems.

Intensive seed grinding convincingly appears only at the transition to the Middle Holocene. We will not be surprised or dismayed if future investigations ultimately find PHT milling equipment, but we suggest here that the Middle Holocene proliferation of seed grinding implements signals a shift in sexual division of labor caused both by the desiccation of Great Basin wetlands and the consequent effects on artiodactyl distributions. We see the proliferation of milling equipment, beginning at the onset of the Middle Holocene, as a key signature of the reorganization of division of labor by gender among Great Basin foragers, and the shift to a permanently divergent division of labor as the primary distinction between Prearchaic and Archaic subsistence strategies in the Great Basin.

4. Conclusion

In this paper we have emphasized the importance of high mobility and convergent division of labor. However, the success of this strategy was predicated on several other interrelated factors, summarized in Table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Aspects of Prearchaic Adaptation.</th>
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</thead>
<tbody>
<tr>
<td>Temporal Scale</td>
<td>Six thousand years, Late Pleistocene to Early Holocene</td>
</tr>
<tr>
<td>Climate</td>
<td>Cooler than Holocene and relatively moist but variable at many temporal scales</td>
</tr>
<tr>
<td>Resource Patches</td>
<td>Homogeneous (wetlands), abundant</td>
</tr>
<tr>
<td>Key Resources</td>
<td>Reliable large game, inexhaustible plants and small game</td>
</tr>
<tr>
<td>Maximum Range</td>
<td>Very large</td>
</tr>
<tr>
<td>Lithic Technology</td>
<td>Hunting-oriented but flexible, easily repurposed</td>
</tr>
<tr>
<td>Population</td>
<td>Low, regulated by long birth spacing and climate-induced infant mortality</td>
</tr>
<tr>
<td>Residential Mobility</td>
<td>High, short stays, frequent moves</td>
</tr>
<tr>
<td>Group Size</td>
<td>Small, homogeneous, connected by movement through range</td>
</tr>
<tr>
<td>Division of Labor</td>
<td>Mostly convergent but flexible</td>
</tr>
</tbody>
</table>

While we hope this contribution aids our understanding of PHT life ways, there are several more avenues of investigation that are required to fully developing our model. These include (1) greater precision in understanding the paleoclimatic record and how it directly affected environmental parameters; (2) more precise definitions of PHT resource structure at different intervals; (3) geographical analyses of site location and structure relative to resource distributions at local and landscape scales; (4) more research on animal migrations and (5) a better understanding of lithic production and use. Following these research avenues should provide crucial answers to still lingering questions regarding PHT adaptations. Nonetheless, we point out that there are a number of archaeological testable implications of our framework as it currently stands, most of which correlate with both the size of the PHT wetland and the distance to the nearest alternative basin. We expect that:

1. Prearchaic sites tend to be oriented to streams and riparian zones feeding wetlands.
2. Accumulations of Prearchaic points bearing signs of impact fractures are most likely to appear in locations that would have been most amenable for intercept hunting strategies.
3. While the relative size of toolstone catchments is conditioned by toolstone availability at various scales, in intervals of the PHT when wetlands were most numerous and extensive, human mobility should have been highest, toolstone catchments
largest, and occupational intensity and curation/recycling lowest.  
4. In the waning PHT, as wetlands diminished and distance between surviving ones increased, occupational intensity should increase in sites in isolated wetlands and toolstone assemblages should be dominated by local toolstone and have high curation indices.  
5. Ground stone milling tools are most likely to appear earliest in smaller, more isolated basins, particularly during dryer climatic intervals of the PHT, but as the Middle Holocene is approached, will more frequently appear in larger wetlands.  

We suggest that approaching these questions within the framework we have outlined here provides a clear avenue for future work. However, we emphasize the importance of keeping informed on theoretically driven studies of modern foragers and incorporating their insights into our interpretive frameworks. We acknowledge that, barring discoveries of larger samples of human burials such as those at Buhl and Spirit Cave, it is unlikely that we will be able to directly test our inferences about sexual division of labor in the PHT Great Basin. Nonetheless, such studies, firmly grounded within the theoretical framework of HBC and empirically tested among contemporary foragers, provide a necessary lens for querying an otherwise opaque and paradoxical archaeological record.  

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