During the Neolithic period, human groups in various regions of the world embarked on a new way of life. These groups began manufacturing and using pottery vessels, used the bow and arrow, shifted subsistence patterns from strictly hunting and gathering to horticulture and agriculture, began domesticating animals, and established sedentary villages. Archaeologists and other scholars (e.g., Diamond 2005) have investigated potential causes and consequences of these changes. It has been noted that one major factor contributing to these changes is an increase in population size (Bandy 2005; Bocquet-Appel and Bar-Yosef 2008; Vierra 2004). Archaeologists describe this worldwide phenomenon as the Neolithic demographic transition (Bocquet-Appel 2002; Kohler et al. 2008). This research explores three scenarios to help explain subsistence patterns with regard to the consequent events of the Neolithic demographic change, in particular the aggregation of human groups and the resultant increase in population density in prehistoric societies in the American Southwest from A.D. 900 to 1300. We argue that artifact deposits from a range of settlement sizes can inform meaningful interpretations about the consequences of social processes, such as aggregation and increases in group population density.

Tracking broad-scale behavioral patterns using both lithics and faunal remains offers one line of evidence for investigating both prehistoric subsistence activities and the consequences of aggregation and increases in population size. Accumulation research, which examines the ratio of projectile points to cooking pottery sherds from the same context, shows a higher ratio of projectile points in areas with lower population densities. This pattern holds true when examining faunal assemblages and large-game procurement practices from A.D. 900 to 1300 in southwestern Colorado and southeastern Utah. This research demonstrates that social processes such as aggregation and increases in population density influence human hunting strategies as much as changes in natural environment, which lead to changes in a group’s dietary regime.

El estudio de los patrones de comportamiento humano a grandes rasgos, através de los restos líticos y faunísticos, nos ofrece una línea de evidencia apropiada para la investigación de la dieta prehistórica tal como la del crecimiento de población y las consecuencias de la agregación. Investigación de acumulación, un análisis de la proporción del número de puntas de proyectil relativa a lo de las piezas de cerámica, indique una cantidad alto de proyectiles en localidades con una densidad de población menor (en localidades menos poblados). Este patrón es válido también para describir las colecciones faunísticas y el estudio de estrategias de caza mayor en el suroeste de Colorado y suroeste de Utah desde 900 a 1300 d.C. Los resultados demuestran el impacto de los procesos sociales, como la agregación y el crecimiento de densidad de población de una zona, en las decisiones sobre el aprovechamiento de los recursos animales, lo cual es de igual importancia como los cambios ambientales, y de dichos decisiones resultan cambios en la dieta general.

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into large-game procurement strategies in southeastern Utah and southwestern Colorado (hereafter referred to as the northern San Juan region) from A.D. 900 to 1300. We contend that accumulation research, using empirical Bayesian Theorem methods verified with faunal data, can be used to examine the relationship among human settlements, distribution, and subsistence strategies and in particular the role of large-game hunting in small, dispersed communities compared with its role in larger population centers. We also investigate differences in procurement patterns of large game in three subregions (McElmo–Yellow Jacket, Mesa Verde, and the Ute Mountains) in the core area that illustrate the consequences of living in densely populated, aggregated communities after the tenth century. Finally, we summarize our findings of subsistence and settlement patterns in relation to social processes, arguing that social processes greatly influenced subsistence patterns of large-game hunting, such as localized overhunting resulting in the depression of game stocks.

The Northern San Juan Region

Archaeological remains from a portion of the northern San Juan region (Figure 1) provide an excellent test case for examining the relationship between population growth and changing prey choice. Following Mahoney et al. (2000), we focus on two subareas: the core, an area of relatively high population density and increasingly aggregated settlement, and a western periphery, typified by relatively low population density and little aggregation (Mahoney et al. 2000; Varien et al. 1996). The core area centers on the McElmo Creek drainage basin in southwestern Colorado (Figure 2) and includes the McElmo–Yellow Jacket, Mesa Verde National Park, and Ute Mountain districts as defined by Varien et al. (1996). The western periphery is confined to southeastern Utah and includes the Canyonlands, Cedar Mesa, and Escalante districts (Varien et al. 1996). These areas were chosen because both are within the ancestral Pueblo culture area, yet collectively, cultural remains recovered from the western periphery are dissimilar from those of the core area because of differences in aggregation and the increase of population density from A.D. 900 to 1300 (Adler 1996; Glowacki 2006; Lipe and Varien 1999a, 1999b; Varien et al. 1996).

The contrast between these subregions is straightforward: between A.D. 900 and 1300, population density in the western periphery was much lower than population density in the core area. Varien et al. have compiled population data from the study region that can be used to gauge relative population densities (Varien et al. 1996; Varien et al. 2007). On the basis of reconstructed population data, population density in the core area from A.D. 900 to 1300 was 7 to 11 people per square kilometer, whereas in the western periphery...
ery it is estimated that the population density never exceeded two people per square kilometer during the same period.

**Hunting Strategies in the Prehistoric Southwest**

A recognized problem for sedentary agriculturalists is the need to obtain sufficient protein, fats, and essential vitamins and minerals in diets dominated by carbohydrates (Speth and Scott 1989; Spielmann and Angstadt-Leto 1996). Exchange with neighboring hunting groups (Spielmann 1991) and the use of domesticated turkeys (Driver 2002a; Munro 1994) was a solution in some parts of the Southwest. Hunting of large and small game, however, was a more common solution (Cowan et al. 2012; Johnson 2006; Munro 1994; Potter 1995; Shott 1990; Speth and Scott 1989; Spielmann and Angstadt-Leto 1996; Szuter 1991; Szuter and Bayham 1989; Szuter and Gillespie 1994; Vierra 2004).

Optimal foraging theory, particularly the diet breadth model, predicts that large game is preferred over small game due to higher net return rates (Bayham 1977:357; Broughton and Grayson 1992; Grayson and Delpech 1998; Hawkes et al. 1982; Kaplan and Hill 1985, 1992; Madsen 1993; Madsen and Schmitt 1998; Smith 1981; Stephens and Krebs 1986). Spielmann and Angstadt-Leto (1996:83–84) illustrate this point by noting how roughly 50 rabbits would need to be procured to match the protein yield of a single deer. It follows that only when large-game encounter rates decrease do economically minded hunters widen their diet breadth and incorporate more small game into their hunting repertoire. Archaeologists have used artiodactyl indexes (Broughton et al. 2010; Broughton et al. 2011; Byers et al. 2005; Driver 2002b; Spielmann 1991; Spielmann and Angstadt-Leto 1996; Szuter and Bayham 1989) to gauge the prey choices of prehistoric hunters in the American Southwest. Although problems exist in using artiodactyl indexes as a proxy for diet breadth (i.e., differential fragmentation and bone survivorship rates), here we use artiodactyl indexes in conjunction with stone tool and utility ware ratios to determine if hunting strategies at larger communities are indeed different from those at smaller communities during homologous climatic periods.

Artiodactyl indexes from faunal assemblages in the northern San Juan region show substantial variation. Many sites have very low artiodactyl indexes, suggesting that hunters rarely obtained artiodactyls (Brand 1991; Driver 1996, 2002b;
Johnson 2006; Potter 1995). This was the case particularly before the depopulation in the core area around the late A.D. 1200s (Driver 1996, 2002b; Johnson 2006). Increased population density is one factor that might lead to such a shift in prey choice. Studies have found that increased population density and consequent depletion of large game is one causal factor leading to greater emphasis on small game (Cannon 2000, 2003; Cowan et al. 2012; Driver 2002b; Hudspeth 2000; Johnson 2006; Potter 1995). For example, Potter (1995) found evidence for overhunting and increasing exploitation of small game in Pueblo IV (A.D. 1300–1600) sites in central New Mexico. In this case, not only did the artiodactyl indexes decrease, but also the carcasses of the few artiodactyls procured were intensively processed for bone grease and marrow, generally an indication of potential resource stress (Burger et al. 2005). Driver (1996, 2002b), Muir (1999), and Muir and Driver (2002) have also found evidence for over-hunting of artiodactyls in the northern San Juan faunal assemblages. They note decreasing artiodactyl indexes where populations were dense and suggest that the pattern resulted from a shift to domestic turkey as an important source of protein from A.D. 1225 to 1300.

**Projectile Points and Large-Game Hunting**

Southwestern archaeologists have long noted the relative paucity of projectile points in sites throughout the American Southwest (Morris 1939), yet few testable ideas have been presented to explain this pattern. One basic assumption is that flaked-stone tools defined by investigators as projectile points are in fact weapon tips and are not, for instance, hafted knives, drills, or scraping tools. This is probably a reasonable assumption since examples of projectile points hafted to what are clearly dart and arrow shafts are known from ethnographic documentations (Churchill 1993) and dry cave sites in the region. This does not mean that all projectile armaments were made of flaked stone, and in fact, it is likely that many were bone or wood (Morris 1939; Rohn 1971:107). This is a possible source of bias in the current study. If there was regional or temporal variation in the frequency with which organic projectiles were used relative to stone-tipped projectiles, this could produce misleading patterns. However, we argue that weapon systems were similar across the study area since other aspects of material culture are rather consistent.1

Another assumption is that stone-tipped projectiles were used on large rather than small game. Cross-cultural ethnographic data provide strong support for this generalization. Ellis (1997) surveyed 79 societies with data recorded for projectile use and found that over 96 percent of the groups used stone-tipped projectiles exclusively on large game and that organic armaments were almost exclusively used for small game. While both stone and organic tips may be used on large game, stone tips were used for small game in few cases. Furthermore, in these few cases the small animals were at the large end of an arbitrary size cutoff (40 kg). Small animals such as rabbits and small birds, the primary small game in the northern San Juan, were only hunted with organic-tipped weapons (Ellis 1997).

Another possible use of stone weapon tips is in warfare, a pattern also identified in Ellis’s (1997) cross-cultural study. Evidence for conflict in the prehistoric Southwest is abundant (Kohler and Turner 2006; Kohler et al. 2006; Kohler et al. 2008; Kuckelman 2002, 2010; Kuckelman et al. 2000; LeBlanc 1999), especially before the depopulation around the late A.D. 1200s in the northern San Juan region. For example, Kuckelman (2002, 2010; Kuckelman et al. 2000) reports that when settlements became aggregated in the central Mesa Verde region during the thirteenth century, archaeological evidence of warfare or violence increased. On the basis of this result, it is possible that projectile points served as offensive or defensive weapons, as well as hunting tools. This is one alternative to the hypothesis presented here and should also be considered in explaining variation of the projectile point frequencies in the northern San Juan region. To the extent that warfare is associated with later and larger settlements, predictions for projectile point patterning resulting from human conflict are the opposite of those for the hunting hypothesis.

**Accumulation Research**

The study of the subsistence behavior patterns of prehistoric groups is typically approached with di-
rect evidence such as plant and animal food remains and residues, coprolites, and isotope data from human skeletal materials (Decker and Tieszen 1989). These remains often require special preservation conditions and are subject to numerous taphonomic biases and postdepositional degradation (Behrensmeyer 1978; Lyman 1984, 1994; Marean 1991; Todd and Rapson 1988). Not all such lines of evidence are always present in all archaeological contexts, nor is the interpretation of these remains straightforward. The organic record of prehistoric diet and subsistence activities can exhibit ambiguous patterning with respect to their behavioral correlates (Spielmann and Angstadt-Leto 1996:84–85).

In contrast, stone tools and by-products of their manufacture and maintenance are well-preserved elements of the archaeological record, sometimes the only preserved element, and while they are typically analyzed to address questions related to technology and land use, there is untapped potential to derive subsistence information from them. Wilshusen (1999:185), for example, has suggested that information on broad trends in site distributions, site function, storage features, and artifact accumulations compiled from the substantial literature on the Southwest may be useful for inferring subsistence behavior. Part of the rationale for taking this broad approach is the hope that the sheer volume of data might mitigate biases resulting from single, anomalous data points and that robust, behaviorally meaningful patterning will be evident.

**Methods**

During the post-habitation site-formation process (Schiffer 1995, 1996), a wide variety of factors may have influenced the numbers of artifacts recovered and reported by archaeologists. The duration and timing (seasonality) of site occupation and settlement population size surely affected the number of projectile points deposited at a site. All else being equal, intensively occupied sites simply have more opportunities for projectile points and other refuse to accumulate in comparison to ephemerally used sites. The function of a site also affects how many projectile points could be accumulated in each site. For instance, it is generally assumed that a hunting campsite should...
have more projectile points than a campsite that is associated with plant harvesting. Thus, this study focuses only on habitation sites where people lived year-round in order to minimize sampling errors.

Projectile point frequencies may also differ from site to site as a result of different archaeological sampling, excavation, and recovery strategies. Sites in the database assembled for this study, for example, have been sampled with varying degrees of intensity; some have small surface collections, while others have been subjected to large-scale excavations. Fully excavated habitation sites should, in theory, contain more projectile points than those with only limited surface collections or small-scale excavations, and simple comparisons are not comparable. Furthermore, the recovery methods of projectile points would create biases in this research. Many of the earlier excavations did not involve screening, and some may not have involved collecting all classes of artifacts with equal intensity. To resolve these sampling issues, we identify three points to justify our research on the accumulation of projectile points.

To control for both systemic and archaeological influences on projectile point frequency in

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<th>Site name</th>
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*Pecos Terms: PII=Pueblo II; PIII=Pueblo III. District: CM=Cedar Mesa; CL=Canyonlands; ES=Escalante. Site-Type: SH=Small Habitations; LH=Large Habitations; VL=Villages. Site Size SM=Small; LG=Large.
In this study, we use a modified version of a methodology first suggested by Bruce Bradley (1988). His excavations at the Wallace Ruin site produced what appeared to be a large number of projectile points. In an attempt to determine whether the large absolute number of projectile points reflected intensive use and discard of projectile points or was simply a product of large-scale archaeological investigations, Bradley compared projectile point frequencies among a group of sites. He sought to standardize projectile point frequencies using the volume of excavated deposit, structure count, or area of excavation but found that such data were inconsistently reported. As an alternative, he reasoned that serving pottery (whiteware) sherds might serve as a useful measure for the comparison of projectile point frequencies among many sites because of the ubiquitous distribution of this pottery type throughout the Southwest and the presumed constant rate of discard and accumulation of these wares.
Inspired by Bradley’s research, we use utility ware (grayware) sherds that were widely reported by excavators for this study. Grayware jar sherds in particular were primarily used for cooking because ancestral Puebloans had a relatively small variety of cooking practices. Standing inventories and rates of the accumulation of cooking pottery sherds should be more closely related to population size at a settlement than inventories of serving pottery sherds, as well as other types of pottery remains (Lightfoot 1994; Varien and Mills 1997; Varien and Ortman 2005). Therefore, we argue that utility ware sherds could be used for standardizing interassemblage comparisons. An implicit assumption, substantiated by other studies (e.g., Schlanger 1990), was that the accumulation of pottery grayware sherds was more uniform between sites than was the accumulation of other artifacts. Utility ware sherds particularly have been found to be a good measure of site occupation intensity (Kohler 1978; Lightfoot 1993, 1994; Varien and Mills 1997; Varien and Ortman 2005; Varien and Potter 1997) and thus can serve as a means of standardizing data for intersite comparisons.

Accumulations research is concerned with the dynamic relationship among artifact discard, the duration of site occupation, and population (Lightfoot 1993, 1994; Varien and Mills 1997; Varien and Ortman 2005). Ethnoarchaeological, experimental, and archaeological studies of pottery cooking vessels show them to have relative short use lives, to exhibit a narrow range of variation in use life, and to occur with relatively high frequencies in given assemblages (David 1972; Foster 1960; Lightfoot 1994; Schlanger 1990; Varien and Ortman 2005; Varien and Potter 1997). Sites are expected to accumulate utility ware sherds at consistent and fairly rapid rates because cooking pots are subject to daily use and thermal stress, are used at most sites, and perform similar functions from site to site (Lightfoot 1993, 1994; Varien and Mills 1997; Varien and Ortman 2005). Given a known quantity of sherds and an estimate of site occupation duration or site population, other variables can be estimated. A ratio of projectile points to grayware sherds from a site should therefore be able to control for effects on assemblage patterns that result from site population and occupation duration, as well as intersite assemblage variation produced by different sampling and recovery procedures. This assumes that points are discarded in similar places as sherds and that rates of discard of points are not greatly different from rates of discard of cooking potsherds. In other words, if points were discarded at much lower rates, then this would depress the number of points recovered in assemblages at short-lived sites.

Projectile points recovered from residential sites may enter the archaeological record in several ways. On the basis of site-formation processes (Schiffer 1995, 1996), discarded projectile points may have gone through various cultural and natural processes. For example, damaged points may be brought back from hunts lodged in meat packages, or they may be discarded in the process of repairing weapons. Such rehafting may occur at residential sites or away from settlements during hunting forays. If the logistics of weapon repair varied systematically through time or between sites, this would influence the patterns in this study. With the broad database used here, however, and with sites that represent relatively lengthy occupation durations (i.e., more than a year), these variations even out and should not significantly influence observed patterns.

Finally, we argue that the sampling method used to recover stone artifacts (e.g., with or without screening) is not a major factor for this study. According to a study of confounding variability in the Dolores Archaeological Program, Kohler et al. (1988) found that there was no significant correlation between many different collection practices (screening vs. not screening) in the relative representation of most artifact categories, including projectile points. Regarding the recovery of faunal remains, it is known that the use of differently-sized screens in excavations affects the relative abundances of different-sized taxa (e.g., Cannon 1999; James 1997; Nagaoka 1994; Shaffer and Sanchez 1994). Thus, the artiodactyl index would be affected by sites that were not screened because small-mammal bones may have been missed, creating a sampling bias. Although it is likely that the recovery techniques at all sites used in this study were different, some proportion of small-mammal bones present in the deposits was recovered without the use of screens. The artiodactyl and lagomorph NISP data used herein have been developed into artiodactyl indexes by other researchers (Badenhorst 2008; Driver...
2002a; Muir and Driver 2002) and serve as a heuristic device to determine the effectiveness of projectile point ratios in identifying large-game hunting intensity.

**Empirical Bayesian Methods**

Importantly, for sites with no projectile points (10 of 72 sites), we use empirical Bayesian statistical methods of parameter estimation (see Robertson 1999 for a detailed description of this methodology). According to Robertson, Bayesian statistics provide:

A method and rationale for formally integrating prior beliefs or evidence about a population parameter with new empirical information derived from a sample of that population; the goal being an improved posterior estimate, one that is likely to be closer to the true value of the parameter of interest, with a smaller standard error and variance [1999:139].

In other words, Bayesian statistics allows us to account for small or absent samples using a priori knowledge of the sample data. In this research, we use the sum of projectile points and grayware sherds (the prior values in this case), values that are most likely to be observed within any single sample.

Simply put, each site assemblage is assumed to be a sample from a larger population; thus, the prior estimate represents the proportion of interest in the population from which that particular site assemblage was analyzed. The prior information comes from combining the information from many sites and then using the mean and standard deviation of the proportion of those site assemblages to estimate \( a \) and \( b \), which are parameters that define a beta distribution used as a prior probability distribution for each site. Using a beta distribution for the prior information is useful because it allows a posterior estimate to be calculated by combining \( a \) and \( b \) from the prior probability distribution with the number of projectile points and the sample size from each site.

We began by aggregating data from sites in the core area and the western periphery, respectively. Then, we used Bayesian statistics to estimate the posterior mean (\( \mu'' \)) of the quantity of projectile points for sites with either the presence or the absence of projectile points (Robertson 1999). It is important to note that we applied the Bayesian method to the count of projectile points and grayware sherds recovered from all sites. The posterior mean was calculated using the following equations:

\[
a = \mu \left[ \left( \frac{\mu' (1 - \mu')}{\sigma} \right) - 1 \right]
\]

\[
b = (1 - \mu') \left[ \left( \frac{\mu' (1 - \mu')}{\sigma} \right) - 1 \right]
\]

\[
\mu'' = \left( \frac{n + a}{n + a + b} \right)
\]

where

- \( a \) and \( b \) are two nonnegative constants (i.e., standardized means for the distribution of the sample proportion), and the values of the variable always range from 0 to 1
- \( \mu'' \) = posterior mean value
- \( n \) = the sum of projectile points and grayware sherds at the site
- \( \sigma \) = sample standard deviation
- \( \mu' \) = sample mean

We compared a posterior mean (\( \mu'' \)) by the mean of projectile points based on the sum of projectile points and grayware sherds recovered from sites in the core area and the western periphery area. When the posterior mean value (PMV) is low, this indicates that projectile points were discarded at much lower rates in assemblages. Furthermore, we suggest that lower ratios of projectile points may indicate a reduced focus on hunting large game and a shift to hunting small game and the incorporation of domesticated turkey into the diet, both of which are fundamental shifts in a group’s dietary regime.

**Artiodactyl Indexes**

In addition to deriving a PMV for each site, artiodactyl indexes were created for the same sites. NISP values for all artiodactyl and lagomorph remains were tabulated from the available literature and artiodactyl indexes, thus tracking artiodactyl hunting success rates and providing a general index of diet breadth. Lower artiodactyl indexes correlate with larger amounts of small game and larger overall diet breadth of a group (Byers et al. 2005).

\[
\theta = \mu' \cdot \frac{1 - \mu'}{\sigma}
\]

\[
\sigma = \sqrt{\frac{\mu' (1 - \mu')}{n + a + b}}
\]
Plotted against PMV, a four-quadrant graph (the four quadrants separated by the variables’ mean value) depicts the relationships between the accumulation study and the artiodactyl indexes (Figure 3). According to our hypothesis, large sites with high population densities should fall in the lower left quadrant, representing both few large-mammal remains and few projectile points due to overhunting and resource depletion. Inversely, small sites in areas with low population densities should exhibit larger numbers of large mammals and thus higher numbers of projectile points, as represented by the upper right quadrant.

**Results**

**Posterior Mean Value**

The average PMV for all sites in the sample is .0086. Comparison of the PMVs between all sites in the western periphery ($\mu^* = .015$) and in the core area ($\mu^* = .002$) shows that the western periphery is rich in projectile points, as indicated by a high PMV based on the Bayesian calculation. It is obvious that the PMV of small settlements in the western periphery is more than 10 times higher than in the core area. In other words, on a regional scale, the less-populated western periphery has more projectile points compared with the core area.

There is also strong patterning in the regional distribution of large and small sites. The western periphery is dominated by small sites (89 percent), whereas the core area has a more balanced split between large ($n = 25$) and small ($n = 11$) sites. At local scales, small sites generally have higher PMVs than large hamlets and villages in both areas. When comparing small and large western periphery sites ($t = -1.45; df = 34; p = .16$), the differences are not statistically significant (Figure 4). In comparison, core small and large sites ($t = 2.85; df = 33; p = .0075$) are statistically more similar (Figure 4). At the regional scale, however, the difference between western periphery small sites and core small sites ($t = 2.81; df = 41; p = .0075$) and western periphery large sites and core large sites ($t = 6.60; df = 27; p = .0001$) is significant.

We further examined PMV in three districts making up the core area (Ute Mountain, Mesa Verde, and McElmo–Yellow Jacket) from A.D. 900 to 1300. The aim of this examination is to compare differences in the ratios with regard to different population densities. On the basis of the similar study area used by the Village Ecodynamics Project (Varien et al. 2007), researchers documented that a range of 2,000 to 19,000 peo-

![Figure 3. Four-quadrant graph of the distribution of the artiodactyl index vs. posterior mean value.](image-url)
ple potentially inhabited areas in the McElmo–Yellow Jacket district from A.D. 900 to 1300. The McElmo–Yellow Jacket district was the most highly populated area, followed by the Mesa Verde district and then the Ute Mountain district (Wilshusen 2002:114). The results suggest that the average ratio from the McElmo–Yellow Jacket district displays the highest PMV \( \mu' = 0.0026 \), followed by the Ute Mountain district \( \mu'' = 0.0018 \). The Mesa Verde district shows the lowest average ratio \( \mu''' = 0.00045 \), indicating few points relative to utility ware sherds (Figure 5). A one-way analysis of variance was used to test for differences among PMVs for large sites in these three areas of the core. The result shows that these areas are significantly different \( F = 9.303; p = 0.0012 \), and the low PMV for Mesa Verde is in line with our hypotheses. It is also expected that sites from the Ute Mountain district have relatively high PMVs because the area has lower population densities than other districts. However, we did not expect a very high PMV from sites in the McElmo–Yellow Jacket district because population density in that subregion was the densest of the three subareas in the northern San Juan region from A.D. 900 to 1300 (Varien et al. 2007).

**Artiodactyl Index**

Our hypothesis that large sites with higher population densities should exhibit lower PMVs, which reflects a reduction in large-game hunting, should also be evident with the faunal remains (as indicated by a low artiodactyl index). First, we examine the relationship between PMVs and artiodactyl indexes at small sites in the western periphery vs. small sites in the core (Figure 6). Eighty-four percent \( n = 27 \) of small western periphery sites have artiodactyl index values above the sample mean \( 0.632 \), indicating that hunters from these small sites were procuring higher amounts of large game vs. small game. Eighty-eight percent \( n = 38 \) of all small sites also have PMVs above the mean \( \mu' = 0.013 \). One hundred percent of core area sites and 53 percent of western periphery sites fall below the PMV mean. Although 90 percent of the western periphery sites had high artiodactyl index values (indicating a focus on large game), only 46 percent of these sites also had a PMV above the mean, which, accord-

![Figure 4. Comparison of small and large sites' median, mean, and range posterior mean values in the western periphery and core areas.](image-url)
According to our hypothesis, is also linked to large-game hunting. It is not clearly understood why there are sites with PMVs below the mean (indicating few projectile points) and artiodactyl index values above the mean (indicating a focus on large-game hunting). A similar mystery lies with the two western periphery sites that have high PMVs and low artiodactyl indexes.

Figure 5. Comparison of median, mean, and range posterior mean values of core area sites.

Figure 6. Number of small sites in each posterior mean value/artiodactyl index quadrant.
Interestingly, only two small western periphery sites fall in the lower left quadrant, indicating both few artiodactyl remains and few projectile points recovered from the sites. All of the small core sites fall into the lower left quadrant, indicative of having both few artiodactyl remains and few projectile points. Unfortunately, no small Mesa Verde sites had faunal data relevant to this study.

Data from large sites demonstrate yet another pattern (Figure 7). Forty-four percent \((n=13)\) of all large sites fall into the lower left quadrant, having few large-mammal remains and few projectile points; all of these are sites from the core. Eighty percent \((n=20)\) of the large core sites also have artiodactyl index values below the mean (0.2543). Not surprising are four large western periphery sites in the upper right quadrant, indicating large proportions of artiodactyl remains as well as large numbers of projectile points. No western periphery sites were in the upper left quadrant (with a high artiodactyl index value and low PMV).

When looking at artiodactyl index values from core area sites, the large Mesa Verde sites stand out. Five of the seven Mesa Verde sites fall into the upper left quadrant, indicating numerous artiodactyl remains and few projectile points. Other sites within the core area subregions have low artiodactyl index values (McElmo–Yellow Jacket mean = 0.0496; Ute Mountain mean = 0.0458), which fits with our hypothesis that densely populated areas should have low artiodactyl index values. Although faunal studies in the Mesa Verde subregion are few, Muir and Driver (2002) speculate that high levels of artiodactyls are due to lower human population densities within the Pueblo III period.

**Discussion**

One benefit of a broad regional study such as this is that it provides a larger perspective on the variability of assemblage patterns. Only when we employ the empirical Bayesian methods, which estimate the proportion of projectile points relative to the sum of projectile points and utility ware sherds in the unknown population of each site assemblage, can we understand the frequency of projectile points at a specific site in a broader context. The ability to standardize artifact frequencies relative to site occupation intensity serves to further
highlight characteristics of assemblages and put them into a framework of larger patterns. The fact that sites of similar size in the same district/local area have similar frequencies of projectile points suggests a shared causal factor. On the other hand, this method also highlights interassemblage variation and helps us recognize those that are outliers by some measure. For example, given the trends identified in this study, large hamlet and village sites in the Mesa Verde district are expected to exhibit similar posterior mean values to those of the Ute Mountain and McElmo–Yellow Jacket districts. Interestingly, however, sites in Mesa Verde National Park (MVNP) contain much lower PMVs relative to sites in the McElmo–Yellow Jacket and Ute Mountain districts (Figure 4). According to the PMV analysis, one might predict that the residents of the Mesa Verde district relied less on large game, but the analysis of faunal remains showed that they did in fact utilize large game. According to Driver’s (2002a) regional study in the northern San Juan, sites in Wetherill Mesa of MVNP had large proportions of artiodactyls compared with the faunal assemblages of other subregions. On the basis of the faunal data, we would expect a relatively high amount of projectile points on and around MVNP, but our PMV data yielded contradictory results.

We can consider two possible explanations for the different faunal distributions in MVNP compared with other regions. First, residents in and around MVNP may have more frequently used projectile points in field hunting, during which they reshaped points away from the habitation site and did not bring them back to their households for repair (Binford 1979). Second, residents in MVNP may have obtained large game through trade from other regions, particularly the western periphery area where a high PMV and artiodactyl index is demonstrated by this study. Future research in the area should investigate why there are so few projectile points in the context of a large number of artiodactyl remains in and around MVNP, but our PMV data yielded contradictory results.

Another unexpected result from this research is a higher PMV in the McElmo–Yellow Jacket district (PMV $\mu^* = .0026$; artiodactyl index mean = .0496) vs. the Ute Mountain (PMV $\mu^* = .0017$; artiodactyl index mean = .0458) and Mesa Verde districts (PMV $\mu^* = .0044$; artiodactyl index mean = .5095). In the core area, the McElmo–Yellow Jacket district was the most densely occupied area from A.D. 900 to 1300, and large aggregated settlements were prominent (Varien et al. 2007), yet it had the highest PMV of the three core districts. One possible explanation is that people in this district might have participated in frequent warfare or conflicts—that the need to manufacture and use more projectile points from A.D. 900 to 1300.

Archaeological evidence supports our alternative hypothesis that an increase in conflicts and violence occurred in the McElmo–Yellow Jacket district, especially during the late A.D. 1200s (Kohler and Turner 2006; Kohler et al. 2006; Kohler et al. 2008; Kuckelman 2002, 2010; Kuckelman et al. 2000; LeBlanc 1999). So our alternative hypothesis of projectile points as offensive or defensive weapons could be supported there. This hypothesis should be considered in explaining variation of the projectile point frequencies in the subregion and needs further examination. And as previously noted, it is important to further investigate the seemingly contradictory pattern between the low posterior mean and high artiodactyl index values from MVNP.

Conclusion

This research explores the hypothesis that the frequency of specific artifact classes, in this case projectile points and pottery sherds, allows archaeologist to make meaningful intersite comparisons of subsistence patterns as they relate to social processes related to population aggregation and increase. The artifact frequency patterns iden-
Arakawa et al.]  THE CONSEQUENCES OF SOCIAL PROCESSES 15

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17

AQ78(1)Arakawa_Layout 1 12/6/12 3:59 PM Page 17

Arakawa et al.)


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Notes

1. The weakness of this argument is an assumption that everyone starts over with a “new” inventory of material culture at each site; in other words, the process of creating projectile points is assumed to be similar in each site. Since the majority of projectile points recovered from the northern San Juan region are small side- or corner-notched points from A.D. 900 to 1300, and these points were mostly manufactured expeditiously, we argue that similar discard processes could have occurred at each site.

2. The proportion of projectile points within each collection (p) was generated by dividing the count of grayware sherd (x) recovered from the western periphery and core areas. The mean and standard deviations for the P values for all collections in which n was more than 20 (98 collections) were calculated and used to derive values for a and b. Using the proportion of x and n, we obtained the values .222 and 22 for a and b for both the western periphery and the core areas. These values are then used in turn to calculate posterior estimates for the mean of projectile points in individual collections.

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