Published in final edited form as:

Kiva. 2016 ; 82(3): 232–258. doi:10.1080/00231940.2016.1214055.

Demographic and Social Dimensions of the Neolithic Revolution in Southwest Colorado

Scott G. Ortman^{1,2,3}, Shanna Diederichs^{2,4}, Kari Schleher², Jerry Fetterman⁵, Marcus Espinosa⁶, Caitlin Sommer²

¹Department of Anthropology, University of Colorado Boulder, 233 UCB, Boulder, CO 80309.

²Crow Canyon Archaeological Center, 23390 Road K, Cortez, CO 81321.

³Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, NM 87501.

⁴Department of Anthropology, Northern Arizona University, PO Box: 15200, Flagstaff, AZ 86011.

⁵Woods Canyon Archaeological Consultants, Inc., 206 North Washington Street, Cortez, CO 81321.

⁶Museum of Natural History, University of Colorado Boulder, Boulder, CO 80309.

Abstract

Domesticated food production is widely acknowledged as a crucial innovation that led to significant transformations in human demography and social organization. Here, we address demographic and social dimensions of the Neolithic Revolution in the Mesa Verde region of Southwest Colorado. We first propose a new method of dating habitations to one of two phases of the Basketmaker III period (AD 600–725) using relative frequencies of vessel forms in pottery assemblages. Then we adapt this method to new survey and excavation data from Indian Camp Ranch to investigate demographic processes behind the formation of Mesa Verde Pueblo society. Finally, we investigate the distribution of agricultural storage space across Basketmaker III households to investigate the development of private property during this period. Our results indicate that both in-migration and intrinsic growth were involved in the formation of Mesa Verde pueblo society; that agricultural households initially clustered around public architecture but became increasingly dispersed over time; and that household agricultural outputs took the form of a log-normal distribution typical of societies with private property rights. Collectively, these findings provide evidence that private property rights co-evolved with the commitment to agriculture and settled communities in Southwest Colorado, as researchers have suggested for other world areas.

Keywords

Relative chronology; Survey methods; Settlement patterns; Neolithic Revolution; Basketmaker period; Mesa Verde region; US Southwest

The adoption of domesticated food production set in motion one of the great transformations in human history. In this paper we focus on two dimensions of this “Neolithic Revolution.”

The first is a demographic expansion, often referred to as the Neolithic Demographic Transition, that is apparent in settlement data and age-at-death distributions of human

skeletal remains (Boquet-Appel 2002; Boquet-Appel and Bar-Yosef 2008; Boquet-Appel and Naji 2006; Downey, et al. 2014; Kohler, et al. 2008; Kohler and Reese 2014; Shennan, et al. 2013). The second is the co-evolution of agriculture, community institutions and private property, as is reflected in the appearance of public architecture, the emergence of settlement clusters, and increasing investment in household architecture and furniture (Bandy and Fox 2010; Bowles and Choi 2013; Flannery 1972, 1976; Hodder 1990, 2006; Kuijt 2000; Lipe and Hegmon 1989; Thomas 1999). These changes are evident in the histories of early agricultural societies worldwide, but in many areas the archaeological record is too coarse-grained to observe these transformations in progress. An exception is the northern U.S. Southwest, where early agricultural sites were generally occupied for only short periods, and many have been excavated and directly dated using dendrochronology and other methods.

Our study focuses on local expressions of the Neolithic Revolution in the Central Mesa Verde region of Southwest Colorado. We first explore the possibility of a refined ceramic chronology for the earliest period of agricultural settlement in the region, known as Basketmaker III (AD 600–725), using a calibration dataset of well-dated pottery assemblages. Then, we incorporate the results from this work in an analysis of survey and excavation data from a 485 hectare study area. Our results suggest (1) the formation of Mesa Verde Pueblo society involved both robust intrinsic growth and rapid in-migration from adjacent areas; (2) the creation of public goods, in the form of public architecture and associated activities and institutions, was at the vanguard of community development; and (3) the concept of private property in land and agricultural produce appears to have emerged as this society took shape.

Background

Recent research on the origins of the Pueblo tradition suggests that it formed through the intermingling of immigrant agricultural groups from Southern Arizona with indigenous hunting and gathering groups of the Colorado Plateau (Geib 2011; LeBlanc 2008; Matson 2002, 2006). According to this model, the Western Basketmakers represent the immigrant farmers who arrived by 400 BC (Coltrain, et al. 2007), and the Eastern Basketmakers represent indigenous hunter-gatherers who began experimenting with agriculture by 800 BC and became committed maize agriculturalists by the first few centuries AD (Coltrain, et al. 2006: Figure 20–2; Sesler and Hovezak 2002).

The earliest agricultural settlements in the northern Southwest tend to occur on relatively low-lying areas near permanent streams (Eddy 1961; Geib 1996; Hovezak and Sesler 2006; Lipe 1970; Matson 1991; Matson, et al. 1988; E. H. Morris and Burgh 1954). The central Mesa Verde region was not one of these areas. However, after AD 600 there was a rapid expansion of population in the central Mesa Verde region and other upland areas that are well-suited to dry-land agriculture (Wilshusen 1999). This expansion may reflect the evolution of maize varieties that were better-adapted to the colder and drier climate of the Colorado Plateau (Matson 1991). As a result, by AD 800 the regional population had increased to at least 5,000 (Schwindt, et al. 2016; Varien, et al. 2007; Wilshusen, et al. 2012; Wilshusen and Ortman 1999).

The rapid increase in Pueblo populations between 600 and 800 was probably due at least in part to robust intrinsic growth, as suggested from age-at-death distributions of human skeletal samples; specifically, the fraction of individuals at least five years old that died before age 20, often referred to as the *juvenility index* (Kohler, et al. 2008; Kohler and Reese 2014; Wilshusen and Perry 2008). This local manifestation of the Neolithic Demographic Transition was supported by several improvements in the subsistence economy that only came together around AD 600, including the introduction of starchy maize varieties (Kohler and Glaude 2008:97), the adoption of beans, and the development of true cooking pottery (Ortman 2006: 102–103). The adoption of this full Neolithic economic package resulted in a complete vegetable protein mix within a purely agricultural diet. Measurable increases in intrinsic growth rates were the result.

Migration must have also been involved in the colonization of the central Mesa Verde region, but the relative contribution of migration and intrinsic growth to the population that was in place by AD 725 has been difficult to gauge due to relatively-imprecise dating of unexcavated Basketmaker III sites. For example, a significant accomplishment of the Village Ecodynamics Project (VEP) is a paleodemographic reconstruction for portions of the central Mesa Verde region (Ortman, et al. 2007; Schwindt, et al. 2016; Varien, et al. 2007). This was created by compiling a database of information for all recorded sites, building a calibration dataset of artifact and architectural data from excavated and well-dated site components, and analyzing both in a Bayesian statistical framework to estimate the occupational history of each site. Based on the available calibration data, VEP researchers subdivided the ancestral Pueblo occupation into fourteen modeling periods dating between A.D. 600 and 1280. Most of these periods were 40 years in duration; however, the initial period, which corresponds to Basketmaker III, was 125 years in duration, more than three times longer than the average.

This inability to subdivide the Basketmaker III period into shorter chronological intervals is problematic because artifact accumulations associated with residences dating to this period suggest they were only inhabited for 8–15 years (Varien and Ortman 2005). This means that, over the course of the initial VEP modeling period of 125 years, each family lineage could have built, inhabited and abandoned 9–16 pit houses that look “contemporaneous” with respect to the VEP calibration dataset. So even though the most common site type in the VEP database is a Basketmaker III habitation, the average momentary population of this period may have been the lowest of the entire sequence. To determine how many people “seeded” this landscape around AD 600 or how fast the population actually grew between 600 and 725, it is necessary to develop methods that allow one to distinguish shorter archaeological phases within Basketmaker III. We present research geared toward solving this problem below.

Improving Basketmaker III Chronology

The VEP calibration data (Ortman, et al. 2007) show that there are no obvious differences in the typological profiles of pottery assemblages dating to the early vs. the late 600s in the Mesa Verde region. However, previous research (Blinman 1988) has suggested the relative abundance of different vessel forms, and especially the relative frequencies of seed jars and serving bowls, changed substantially between AD 600 and 800. In addition, there are

indications that storage features changed from bell-shaped pits to aboveground, slab-lined bins during this same period (Gross 1992). Both changes may be related to the shift from flint/pop to dent/flour maize varieties over the course of Basketmaker III (Kohler and Glaude 2008) (the former were easily stored as seeds/kernels in jars, whereas the latter were best stored on the cob). We take advantage of these observations here in proposing a method for subdividing the Basketmaker III period into two chronological phases, AD 600–650 and AD 650–725.

Table 1 presents summary data for seventeen Basketmaker III habitations for which absolute dates and pottery vessel-form assemblage data are both available. Eight of these sites date between 600 and 650, and nine date between 650 and 725. Figure 1 plots the locations of these sites relative to all recorded Basketmaker III habitations within the current VEP study area in Southwest Colorado (Schwindt, et al. 2016). Pottery assemblage data for several of these sites were collected specifically for this project by Crow Canyon Archaeological Center staff and by students at the University of Colorado Boulder (Espinosa 2015). The remaining data derive from cultural resource management projects that excavated Basketmaker III habitations (Brisbin and Varien 1986; Chenault 2004; Errickson 2000; Horn, et al. 2003; J. N. Morris 1991; Wilson 1991, 1999); and from recent excavations by Crow Canyon Archaeological Center at the Dillard Site (5MT10647), a Basketmaker III village with public architecture (Diederichs, et al. 2014; Sommer, et al. 2015). The typical profiles of the ceramic assemblages from these sites consist of undecorated gray ware vessels of various forms, classified as Chapin Gray or Indeterminate Local Gray; vessels with painted decoration classified as Chapin Black-on-white; and vessels with polished and/or slipped surfaces (but lacking in painted decoration) classified as Early White Unpainted. During Basketmaker III the relationship between form and function was not as close as it would become in later periods (Skibo and Blinman 1999; Crown and Wills 1995) and many vessel forms were essentially skeuomorphs of pre-ceramic gourd containers. Despite this, the most common vessel forms are wide-mouth jars used primarily for cooking; water jars with tall, narrow necks; hemispherical food-serving bowls; and globular seed jars—essentially large gourd-shaped vessels with a small circular opening at the top—used primarily for food storage.

A basic challenge we faced in compiling Table 1 involved accounting for inter-observer variation in the assignment of sherds to vessel forms. This is a special problem for Basketmaker III assemblages for a number of reasons. First, whereas in later periods distinctive paste recipes were developed for vessels with different intended functions, during Basketmaker III a single paste recipe was used for all vessels. Thus, paste characteristics cannot be used to assign Basketmaker III sherds to type or to vessel form. Second, in many cases bowl interiors were not prepared by slipping and/or polishing prior to painting, and as a result it can be difficult to determine whether a small, unpainted rim sherd represents an unpainted portion of a bowl or a seed jar. Finally, vessels were generally shaped by hand and thus have somewhat undulating shapes and curvatures. As a result, it is often difficult to determine vessel form, even for rim sherds, on the basis of shape alone. Indeed, most analysts simply classify all sherds that are not rims and which exhibit no paint, slip or polish as Indeterminate Local Gray Jar sherds by default.

Due to these difficulties, we concluded that there is likely to be significant inter-observer variation in the assignment of small, unpainted rim sherds to vessel form. Painted bowl rims are likely to be identified accurately and consistently across analysts, but we suspect there is significant variation in the assignment of smaller unpainted rim sherds to Chapin Gray bowls vs. Chapin Gray seed jars. The solution we adopted was to include all rim sherds identified as being from seed jars, regardless of ware or type, in our *seed jar rim* category; only Chapin B/W bowl rims in our *B/W bowl rim* category; and only Chapin Gray wide-mouthed jar rims in our *gray ware jar rim* category. We are confident that all sherds that meet these descriptions were assigned to vessel form correctly. Previous studies also suggest that raw counts of rim sherds provide a more reliable indicator of relative abundances of vessel forms than do counts of all sherds (Pierce and Varien 1999; Till and Ortman 2007). We therefore treat the relative frequencies of rim sherds assigned to these categories as estimates of the relative frequencies of vessel forms that were broken during the occupation of a site. In addition, we included reconstructible vessel assemblages Table 1 when these data appeared to provide the best indicator of relative frequencies of different vessel forms. Finally, note that Table 1 includes counts of all sherds (rim and body sherds) assigned to one of our three main vessel classes (seed jar, B/W bowl and other gray ware jar). We include these data because most pottery tabulations from surface surveys do not distinguish rim from body sherds and this gives us a means of comparing patterns based on rim sherds vs. all sherds.

Figure 2 presents scatterplots of the relationship between the occupation date of each site (a point estimate) and two different measures of vessel form assemblages: the ratio of B/W bowl rims to seed jar rims; and the fraction of rims that are from seed jars. These plots show that, although the slopes of the relationships are relatively shallow, the ratio of painted bowl to seed jar rims gradually increases, and the fraction of rims from seed jars gradually decreases, over the course of Basketmaker III. Table 2, which compares the aggregated data across sites assigned to each phase, shows the same patterns: the ratio of painted bowl to seed jar rims nearly doubles, and the fraction of rims from seed jars declines by about 25 percent, between the early and late phase of Basketmaker III. These differences are statistically significant. The same trends are apparent in the whole-assemblage data, but the observed differences are not statistically significant due to the fact that most body sherds are classified as gray ware jars and thus the relative proportions of other vessel forms are smaller overall.

To assess the use of vessel form assemblages to identify early vs. late Basketmaker III sites, we performed discriminant analyses that tested the ability of vessel form data to correctly assign the calibration assemblages to the time period indicated by their associated absolute dates. In the first analysis we tested the ability of the two rim-based measures (B/W bowl rims / seed jar rims; percentage of rims from seed jars) to replicate the chronological classification. The resulting discriminant function (Eigenvalue=1.669, $r=.791$, $P=.001$) correctly re-classified 94.1% (16 of 17) of the assemblages, with only Dead Dog Hamlet (5MT11861) being assigned to the incorrect group. In the second analysis we tested the ability of the two total assemblage measures (B/W bowl sherds / seed jar sherds; fraction of sherds from seed jars) to perform the same classification. In this case, the resulting discriminant function (Eigenvalue=.024, $r=.152$, $P=.850$) reclassified only 47.1% of cases correctly. These results indicate that the ability of vessel form assemblages to assign sites to

an early vs. late phase of Basketmaker III is strong when using rim sherds as the basis of quantification, but is no better than a coin toss when using all sherds.

These analyses demonstrate that there is in fact a time trend in vessel assemblage composition across the Basketmaker III period and that it is feasible to distinguish sites inhabited during the early vs. late portion of this period based on the relative frequencies of major vessel forms. However, practical problems remain in that these trends are obscured in total sherd assemblages, and surface survey tabulations often do not distinguish rim vs. body sherds. Due to these empirical problems, future work on Basketmaker III sites should tabulate sherds by type, vessel form, and vessel part so as to capture the chronological trends in vessel form assemblages identified here.

In the meantime, we incorporate these insights in an *aggregate* analysis of survey and excavation data from Basketmaker III settlements from Indian Camp Ranch, a private residential community in Southwest Colorado. Although we do not attempt to phase individual Basketmaker III settlements, we provide a preliminary estimate of the ratio of early vs. late settlements by considering the distribution of vessel form measures across the study sample. It seems reasonable to treat these measures in aggregate because there are real chronological trends in vessel form assemblages but they are poorly reflected in total sherd assemblages due to sampling error. So long as this error is unstructured across sites, the *distribution* of such measures across a study sample should reflect the relative proportions of sites dating to each period, even if it is not possible to determine which sites date to which period. We apply this logic in the analyses that follow.

Application to Indian Camp Ranch

In the remainder of this paper we combine insights from the dating analysis above with new survey and excavation data to characterize the basic demographic and social processes involved in the formation of Mesa Verde Pueblo society during the Basketmaker III period. The archaeological sites within Indian Camp Ranch were first identified by Woods Canyon Archaeological Consultants during a survey associated with real estate development in the early 1990s (Fetterman and Honeycutt 1994). In 2014, Woods Canyon Archaeological Consultants re-surveyed all Basketmaker III habitation components within the ranch (485 ha), taking care to tabulate vessel forms in addition to type. Surveyors also quantified the food storage capacity of each site by measuring the areal extent and density of surface sandstone slab concentrations adjacent to most pit structure depressions (Shanks 2014). The appendix presents summary data for the 68 Basketmaker III habitation components within Indian Camp Ranch, plus preliminary data from surface archaeology, remote sensing and test excavations by Crow Canyon Archaeological Center at six sites, including the Dillard Site (5MT10647) (Figure 3; Diederichs, et al. 2014; Sommer, et al. 2015).

We estimate the relative size of the early vs. late Basketmaker III population in this area by splitting the histogram of seed jar ratios (the count of seed jar sherds divided by the count of gray ware jar sherds) into two groups. The overall distribution of seed jar ratios is shown in Figure 3. We cut this distribution into two groups, using a cut point of 4 percent, because this is consistent with the calibration data and it places the primary occupation of the Dillard

Site, with a seed jar ratio of 4.18 percent ($>4\%$), into the early phase. This is appropriate because the Dillard Site is dated firmly to the 600–650 Period by absolute dates (Figure 4). Twenty-seven of the thirty-one AMS-C14 dates from this site have midpoints prior to AD 644, and these derive from both the great kiva and residential pit structures. The remaining four dates, which extend into the latter half of the seventh century, derive only from the great kiva. Our preliminary interpretation is thus that the Dillard Site was a small village focused on an early great kiva during the 600–650 Period, with the great kiva continuing to serve as a community center, but with a much smaller resident population, during the 650–725 Period. In this sense, our model for the Dillard Site combines both the sedentary village and periodic group assembly models proposed for large Basketmaker III settlements elsewhere on the Colorado Plateau by placing them in a sequence (Lekson 2009; Wills and Windes 1989; Wills, et al. 2014).

Across the study sample, only 10 of the 69 seed jar ratios are greater than 4 percent, and we therefore infer that only about 14 percent of the Basketmaker III sites in Indian Camp Ranch were inhabited AD 600–650, with the remaining 86 percent being inhabited AD 650–725. This split compares favorably with radiocarbon dating results from test excavations in six of these sites (Figure 5), only one of which (The Dillard Site) has a peak probability of occupation prior to AD 650. Table 3 presents the demographic picture suggested by these estimates. A key observation embedded in this table is that the Dillard Site, which contains as many as fourteen pit structures, dates from Phase 1; whereas most other sites, which most often contain only a single pit structure, date to Phase 2. This allows us to estimate the relative number of pit structures that were inhabited during each phase. These estimates suggest a relatively small initial population roughly quadrupled between the early and late phase, with an implied growth rate of about 8 percent per year. One can derive an independent estimate of the intrinsic growth rate by combining the juvenility index for the Early Pueblo Northern San Juan (Kohler and Reese 2014:Table S2) with life table information (Boquet-Appel 2002:Table 2). The resulting estimate is about one percent per year. Given this, the settlement pattern results suggest that even if only one quarter of settlements were inhabited at any given moment (equivalent to a structure use-life of 12–18 years; see Cameron 1990), substantial in-migration would have been required to produce the AD 650–725 population from the AD 600–650 population. In other words, these data suggest both in-migration and intrinsic growth were involved in the formation of Mesa Verde Pueblo society in the seventh century. And it appears that, of the two forces, migration was most important. This interpretation is consistent with obsidian sourcing studies which indicate that obsidians from three different regions (the Jemez Mountains, Mount Taylor, and the San Francisco Peaks) occur at the Dillard Site (Diederichs, et al. 2014:23). Although Jemez obsidian is most frequent, the overall assemblage is more diverse than is characteristic of later periods (Arakawa, et al. 2011).

We also examine changes in settlement pattern during Basketmaker III by considering the settlement size distribution in light of our pottery dating analysis. Figure 6 presents a histogram of settlement sizes, as measured by the estimated number of pit structures present, for the 69 single-component Basketmaker III sites in Indian Camp Ranch. We assumed that each habitation had at least one pit structure, and we increased this count when necessary based on the number of pit structure depressions, the number of pit-structure anomalies

identified through geophysical imaging at certain sites (Diederichs et al 2015), and/or the number of sandstone concentrations visible on the site surface. It is reasonable to infer the presence of one pit structure per sandstone concentration, even when there is no evident depression, due to the typical association of a single cluster of above-ground storage granaries with each pit structure in excavated sites (Gross 1992; Wilshusen 1988). We also infer that each pit structure was the primary roofed living space of a household based on previous research (Lightfoot 1994; Chenault and Motsinger 2000).

With the exception of the well-dated Dillard Site, which contains as many as fourteen pit structures, most of these settlements contain only one or a few pit structures, and thus were home to only one or a few households. This distribution, combined with the dating of the Dillard Site to Phase 1 and most of the remaining sites to Phase 2, suggests that the much larger Phase 2 population was much less clustered and much more dispersed across the landscape. In fact, nearest neighbor analysis of these settlements suggests the distribution of farmsteads was much more even than would be expected by chance (Fetterman, et al. 2014), and the distribution of BMIII households across the larger VEP study area is more dispersed than simulated household agents (Kohler 2012). These results suggest the BMIII settlement pattern became more dispersed and more evenly-spaced over the course of Basketmaker III.

Finally, we examine the role of private property in the development of Mesa Verde Pueblo society by considering the distribution of extramural storage space for agricultural produce across sites. Figure 7 presents a histogram of extramural storage capacities (estimated as the area $\times$ density of surface sandstone slabs associated with each pit structure) across 84 Basketmaker III households in the study sample (this sample excludes the Dillard site). We chose this measure because data for 16 of the 84 households in the sample are from recently-plowed sites. One would expect plowing to disperse sandstone slabs from surface storage structures, leading to concentrations that are more extensive but less dense than at unplowed sites. Table 4 shows that this is in fact the case. However, the total number of slabs in the original concentration should not be as affected by plowing, so one would expect the product of the concentration area with its average density to control for plowing effects to some extent. Table 4 supports this idea as well. We therefore use the area $\times$ density of sandstone slabs as a more versatile measure of storage capacity in Figure 7.

Note that the histogram is of log-transformed data, and the overall distribution is approximately log-normal. In fact, it is not possible to reject the null hypothesis that this distribution is log-normal (Kolmogorov-Smirnov $P>.2$; Shapiro-Wilk $P=.904$). Restricting the analysis to only unplowed sites does not change this result. This finding is important because socio-economic quantities in both contemporary and ancient societies tend to be log-normally distributed (Abul-Megd 2002; Gomez-Lievano, et al. 2012; Limpert, et al. 2001; Ortman, et al. 2015). Such distributions reflect the multiplicative effects of several independent stochastic variables (such as number of farmers $\times$ labor productivity $\times$ land productivity), and are typically seen in income and wealth distributions in societies characterized by private property (Picketty and Saez 2014). In light of this regularity, it appears reasonable to interpret the log-normal distribution of extramural storage capacities as an indication that Basketmaker III society was characterized by increasingly-secure private property rights in land and in ownership of agricultural produce. It is also of interest

that the Gini coefficient for these data is .703, a very high value that indicates substantial concentration of storage capacity in relatively few households (see Smith et al. 2014).

There is relatively little evidence of above-ground storage at the Dillard site. This site contains at least 14 pit structures, is securely-dated to Phase 1, and accounts for the majority of the Phase 1 population; but surface sandstone slabs occur in only three concentrations encompassing a total of 275m². In contrast, there is a mean of 49 m² of extramural storage area per household (*S.D.* = 80m²) across the 68 residences that have such concentrations and have not been affected by plowing (see Table 4). Since most of these other residences date to Phase 2, these data are consistent with previous studies (Gross 1992) in suggesting that agricultural storage gradually shifted from intra-mural subfloor pits to extramural surface granaries constructed of sandstone slabs over the course of Basketmaker III. The facts that agricultural produce was increasingly stored outside of the house in structures that were publicly-visible, and that the distribution of storage areas across households was log-normal, are both consistent with a scenario in which increasingly-secure private property rights emerged during Basketmaker III. The overall increase in extramural storage across the period is also consistent with the increased emphasis on floury maize varieties that were best-stored on the cob, and thus with the declining incidence of seed jars discussed earlier in this paper.

Discussion

The patterns that emerge from our analyses of the survey and excavation data suggest the initial Basketmaker III population of Indian Camp Ranch was small enough that most could live at the Dillard site and still be either adjacent to fields or within walking distance of fields, in a situation where high-quality land was plentiful. The appearance of public architecture during this initial phase, when the population density was substantially lower, is consistent with findings from other parts of the world which suggest public architecture and communal ritual may have actually contributed to the Neolithic Revolution as opposed to being a response to it (Carr and Case 2005; Curry 2008; Haas, et al. 2005; Schmidt 2000; Shady Solis 2006). However, as the local population density grew, it appears that families increasingly sought to locate their houses on or adjacent to the land they farmed, thus claiming rights to the use of that land and to ownership of the resulting produce. This in turn suggests the development of local land scarcity led to the emergence of usufruct land tenure and a domestic mode of production in which household self-sufficiency was the desired state (see Adler 1996; Sahlins 1972). In the Indian Camp Ranch area, these innovations counteracted the benefits of aggregation and led to an increasingly dispersed population. The great kiva at the Dillard Site may have continued to function as a community center during the 650–725 Period, but even if it did, the Dillard Site does not appear to have continued as a village. In other words, our findings suggest the Dillard site was initially a small village but it became a periodic group assembly site over the course of the 7th century. We suggest it may prove worthwhile to re-examine the evidence from other large Basketmaker III settlements in the Pueblo area (e.g. Shabik'eschee Village) with these results in mind (Lekson 2009; Wills and Windes 1989; Wills, et al. 2014).

Our results are consistent with a scenario in which population growth and in-migration promoted the development of private property and a domestic mode of production during Basketmaker III. Several have argued that the concept of private property must have coevolved with agriculture (Bowles and Choi 2013; Testart 1982) but to our knowledge this study is the first to demonstrate a correspondence between the Neolithic Demographic Transition and the emergence of log-normal distributions characteristic of private ownership of agricultural produce. It is important to emphasize that, although private ownership of farmland and the resulting agricultural produce seems second nature to most people today, such norms are dramatically different than the ethos of food sharing that is typical of hunting and gathering peoples (Flannery and Marcus 2012; Sahlins 1972; Woodburn 1982). It is therefore highly significant that private property rights accompanied the Neolithic Revolution in the US Southwest, as this finding adds support to arguments that private property co-evolved with a commitment to agricultural lifeways world-wide. Our results also add support to previous arguments by Adler (1994, 1996) that an essential function of early agricultural communities was the enforcement of property rights. In fact, settlement data from Indian Camp Ranch suggest the emergence of a dispersed settlement pattern of individual family farmsteads was predicated on the development of community institutions that could enforce usufruct property rights. We would also not rule out the possibility that the transition from an early village focused on the Dillard site great kiva to a later dispersed but still tethered community reflects the transition from a hunter-gatherer ethic of generalized food sharing to an early agricultural ethic involving gifts and exchanges (which imply private property) enforced by community institutions that came to be associated with the great kiva.

The pattern of dispersed settlement and private claims on agricultural land that emerged during Basketmaker III is substantially different than the settlement and land-tenure systems of historic Pueblo societies, which emphasize communal apartment-style dwellings in agglomerated villages, collective ownership of agricultural land by clans or by entire communities, and an emphasis on ritual knowledge as opposed to tangible property as the basis of prestige and status (Brandt 1994; Ford 1972; Forde 1931; Ware 2014; Whiteley 1988; Wittfogel and Goldfrank 1943). Our results suggest these characteristics of historic Pueblo communities are outgrowths of prior experience with more tangible, household-based property rights.

Longitudinal data from Western societies suggest an inherent tendency for material wealth to concentrate in fewer and fewer hands in the absence of countervailing redistributive forces (Picketty and Saez 2014). There are several indications that a similar process characterized ancestral Pueblo history from AD 600–1300. For example, the increasing permanence of domestic architecture, and increasing use of old houses as field houses, suggests agricultural land became increasingly heritable as the Mesa Verde region population grew in the 1000s and 1100s (Varien 1999b, 2012). Also, several analyses of settlement data suggest increasing land pressure over time, such that the largest, longest-lived and most prosperous communities were established earlier and on more productive land than were later communities, which had to invest much more labor to achieve the same yields (Glowacki and Ortman 2012; Schwindt, et al. 2016; Varien 1999a, 1999b). Finally, one might view the Chaco Phenomenon as the ultimate expression of wealth concentration in a society that

emphasized heritable, kin-based ownership of tangible property (Heitman and Plog 2015; Lekson 2015; Plog and Heitman 2010).

Strong private property rights in land, agricultural produce and other tangible property may not have been a significant problem so long as land was plentiful and the population was growing rapidly, as both factors have worked against the accumulation of private wealth in more recent Western history (Picketty 2014; Picketty and Saez 2014). However, it appears that by the 12th century most of the best agricultural land had been claimed (Varien 1999a) and the centuries-long period of robust intrinsic population growth characteristic of the Neolithic Demographic Transition was coming to an end (Kohler, et al. 2008; Kohler and Reese 2014). Under these conditions, strong private property rights combined with a domestic mode of production would have resulted in the concentration of tangible property in fewer and fewer hands. In this way, social institutions that were necessary for the establishment of an agricultural society during Basketmaker III would have fostered unprecedented levels of inequality in later centuries. If so, the dramatically different institutions surrounding tangible and intangible property in historic and contemporary Pueblo societies may have arisen in response to long-term outcomes of the institutions that first emerged during the Basketmaker III period.

Conclusions

We have sought to deepen understanding of the demographic and social processes involved in the Neolithic Revolution in the Northern US Southwest by developing a refined pottery chronology for the Basketmaker III period and then applying the resulting insights to new survey and excavation data from Indian Camp Ranch in Southwest Colorado. Analysis of well-dated pottery assemblages from Basketmaker III sites demonstrates that there is a chronological pattern in the relative frequencies of vessel forms in these sites and that it is possible to distinguish sites that were inhabited AD 600–650 from sites that were inhabited AD 650–725 on this basis. However, these patterns are only apparent at the level of vessels, as reflected in rim sherd frequencies, and are not statistically significant in total sherd assemblages. Thus, future investigators will need to distinguish both vessel form and vessel part if they wish to apply this method more broadly.

We applied these insights in several analyses of new survey and excavation data from Indian Camp Ranch. Excavation results show that the largest Basketmaker III settlement in the area, the Dillard Site, was inhabited AD 600–650. We examined the distribution of seed jar fractions across sites, in light of our chronological analyses, in suggesting that most of the other Basketmaker III habitations in the area were inhabited between AD 650 and 725. Resulting estimates of the total populations of the two phases suggest that both intrinsic growth and continuous in-migration contributed to the rapid build-up of population over the course of Basketmaker III. These results, in light of the settlement size distribution, also suggest that the Basketmaker III population became more dispersed and more evenly spaced over time. We interpret this pattern as reflecting the emergence of usufruct property rights and of community institutions that supported these rights. Finally, we examined extramural storage space found that it increased over time and took the form of a log-normal distribution across households. These patterns are consistent with an increased emphasis on

floury maize varieties and the development of secure private property rights in agricultural produce over the course of Basketmaker III.

Future research on Basketmaker III should focus on tabulating rim sherds by vessel form and should seek additional means of distinguishing early from late Basketmaker III sites, as the ability to reliably-date individual Basketmaker III sites to refined chronological intervals is essential for more detailed settlement, demographic, and social research than we have been able to accomplish here. We nevertheless hope these preliminary results are sufficient to show that the Basketmaker III archaeology of the US Southwest has great potential for general understandings of the Neolithic Revolution worldwide.

Acknowledgements

Portions of this research were supported by the National Science Foundation (BCS-1144918) and by History Colorado (SHF 2012-01-010; 2013-01-042; 2014-01-046). We wish to thank Scott Travis and Tara Travis of Mesa Verde National Park for access to collections within the Mesa Verde Research Center; to Bridget Ambler and Tracy Murphy at the BLM – Anasazi Heritage Center for access to the Payne Site collections; and to Christina Cain of the University of Colorado Museum of Natural History for access to collections from 5MT1. We thank the Indian Camp Ranch Homeowners Association, and individual homeowners, for permission to conduct survey and excavation research on individual properties within this private residential community. Finally, we thank Tim Kohler, Dennis Gilpin, Rich Wilshusen, and several anonymous reviewers for helpful comments on previous versions.

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Figure 1.
Basketmaker III habitations, survey areas, and locations of calibration assemblages in Southwest Colorado.

Figure 2.

Changes in Basketmaker III vessel form assemblages through time: A. Ratios of painted bowl rims to seed jar rims; B. The fraction of rim sherds from seed jars.

Figure 3. Histogram of seed jar fractions (seed jar sherds / gray ware jar sherds) across the Indian Camp Ranch study sample. Bar heights reflect the number of sites at which the fraction is within the bin interval. We use a cut point of .04 to estimate the fraction of Basketmaker III settlements inhabited before and after AD 650.

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Figure 4.
Plan map of the Dillard Site.

Figure 5. Summed posterior probability density distributions for calibrated AMS-C14 dates from Basketmaker III sites in Indian Camp Ranch (Data for all but 5MT10709 from Sommer et al. 2015:Table 1; Output from Oxcal v4 2.4 Brock Ramsey (2013); r:5).

Figure 6.
Distribution of Basketmaker III settlement sizes in the study sample.

Figure 7.

Histogram of log-transformed maize storage volumes (area $\times$ density of sandstone slabs) for Basketmaker III households (N=84) in the study sample. The sample is likely drawn from a log-normal distribution (K-S test $P>.2$; Shapiro-Wilk $P=.904$).

Table 1.

Well-dated Basketmaker III pottery assemblages from the Montezuma Valley.

Site Number	Site Name	Best date (point estimate)	Rims/Vessels ^a				Total sherds ^b			Comment	Source
			Seed jars ^c	B/W bowls ^d	Gray Ware Jars ^e		Seed jars ^c	B/W bowls ^d	Gray ware jars ^e		
5MV117	Pit House B; Earth Lodge B	595	24	12	14		25	50	250	595r tree-ring date.	CCAC research database.
5MT4545	Tres Bobos Hamlet	598	50	17	81		52	73	3554	598vv tree-ring date. The data assume Chapin Gray bowl rims are actually from seed jars.	Brisbin and Varien 1986; DAP Database.
5MT2525	Knobby Knee Stockade	615	70	40	63		70	200	3416	Date is the average of 9 tree-ring- dated features. We assume 1 of 5 white ware bowl sherds is a rim, all seed jar sherds are rims, and all specific gray ware jar forms are rims.	Morris 1991; Wilson 1991:755.
5MV1990	Wetherill Mesa Mini train route	621	17	4	9		19	14	541	621r tree-ring date for the Basketmaker III component.	CCAC research database.
5MT12205	Payne Site	625	150	52	200		212	149	7457	625vv tree-ring date.	Espinosa 2015.
5MV283	Pit House C	628	8	4	11		9	4	281	628vv tree-ring date.	CCAC research database.
5MT9168 ^f	Rabbit	637	9	5	12		593	346	1329	637+rG.	Chenault 2004:2–31, 2–34.
5MT10647 ^g	Dillard Site	644	336	161	251		347	630	11728	Date is the midpoint of the latest AMS date from habitation structures at the site.	CCAC research database; Sommer et al. 2015.
5MT5458		665	26	19	48		31	66	1259	665rB date.	Horn 2003:8–47, 8– 48.
5MT1		676	40	30	72		66	62	2036	676r tree-ring date.	Espinosa 2015.
5MT11861 ^f	Dead Dog Hamlet	680	23	13	20		769	495	5011	649+rG and 680rGB cutting dates.	Chenault 2004:5–67, 5–186.
5DL121B ^f	Cloud Blower Stockade	681	10	7	12		137	14	2000	A cluster of 16 cutting dates between 677 and 685.	Wilson 1999:313, 315–319.
5DL310		685	7	7	3		7	15	118	685rB tree-ring date.	Horn 2003:25–28.
5DL1138 ^f	Vinger Hamlet	689	3	3	8		28	129	1050	8 cutting dates between 684–689.	Wilson 1999:313, 315–319.
5MT8899 ^f		693	4	5	4		105	156	1183	693r tree-ring date.	Errickson 2000:167, 176.

Site Number	Site Name	Best date (point estimate)	Rims/Vessels ^a			Total sherds ^b			Comment	Source
			Seed jars ^c	B/W ^d bowls	Gray Ware Jars ^e	Seed jars ^c	B/W ^d bowls	Gray ware jars ^e		
5MV405	Pit House No. 1; Pipe Line Pit House	700	10	7	17	14	14	633	700r tree-ring date. Early White Unpainted bowl rims included in B/W total.	CCAC research database.
5DL112 ^f	Palote Azul Stockade	700	2	2	2	109	164	2333	700+r tree-ring date.	Wilson 1999:313, 315–319.

- ^a) Rim sherd counts unless otherwise noted.
- ^b) Includes rim/vessel counts and body sherd counts.
- ^c) Includes all sherds identified as seed jars, regardless of type.
- ^d) Includes only Chapin B/W and Early White Painted bowls.
- ^e) Includes only Chapin Gray and Indeterminate Local Gray jars.
- ^f) Vessel counts from structure floors.
- ^g) Data from the Dillard site are as of April 2015.

Table 2.

Summary of changes in vessel form assemblages through time.

Phase	Dates (CE)	Number of sites	Rims					Total sherds				
			Seed jars	B/W bowls	Gray Ware Jars	B/W bowls / seed jars ^a	Fraction seed jars ^a	Seed jars	B/W bowls	Gray ware jars	B/W bowls / seed jars ^b	Fraction seed jars ^b
1	600–650	8	664	295	641	.4443	.4150	1,327	1,466	28,556	1.3180	.0612
2	650–725	9	125	93	186	.7440	.3094	1,266	1,115	15,623	1.6172	.0498

^{a)}These differences are statistically-significant across phases (Mann-Whitney U-Test $P < .05$).

^{b)}These differences are in the same direction as the rim sherd data but are not statistically significant.

Table 3.

Summary of inferred demographic data for the Indian Camp Ranch community.

Phase	Dates (CE)	Total sites	Total households ^a
1	600–650	10	23
2	650–725	59	95

^aFor Phase 1, the estimated total households is the number of pit structures at the Dillard Site (14) plus one household for each of the other nine sites; and for Phase 2, the estimate is the total pit structures in the dataset minus the Phase 1 estimate.

Table 4.

Area, density, and total sandstone slabs at plowed vs. unplowed BMIII houses in the study sample.

	N	Area (m ²)		Density (slabs/m ²)		Total Slabs (Area × Density)	
		Mean	STD	Mean	STD	Mean	STD
Unplowed	68	49.0	90.0	13.0	7.4	672.1	1613.9
Plowed	16	183.3	175.0	5.7	2.8	1028.9	1205.5
<i>P</i> -value (t-test)		.01		.00		.33	