SERVING UP ETHNIC IDENTITY IN CHACOAN FRONTIER COMMUNITIES: THE TECHNOLOGY AND DISTRIBUTION OF MOGOLLON AND PUEBLOAN CERAMIC WARES IN THE SOUTHERN CIBOLA REGION

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A Thesis Submitted in Partial Fulfillment of
The Requirements for the Degree of

MASTER OF ARTS IN ANTHROPOLOGY

WASHINGTON STATE UNIVERSITY
Department of Anthropology

DECEMBER 2007

To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of MELISSA ANNE ELKINS find it satisfactory and recommend that it be accepted.

Chair

ACKNOWLEDGMENTS

Numerous people have helped see this thesis through to completion. I would like to thank my committee, Dr. Andrew Duff, Dr. Tim Kohler, and Dr. Melissa Goodman-Elgar for their valuable comments and constructive criticism. Dr. Andrew Duff, my committee chair, has been crucial to the completion of this project. He has provided me with field and lab work for the duration of my graduate career and has taught me invaluable analysis and writing skills. I wish to thank him for his continued dedication to students, generosity of time and funds, ideas, and access to opportunities.

Several individuals and institutions made my research possible and deserve many thanks. Dr. Andrew Duff's multi-year fieldwork at Cox Ranch and Cerro Pomo Pueblos, under permits granted from the New Mexico office of the Bureau of Land Management, supplied the ceramic data for this project and has been funded by the National Science Foundation (#BCS-054595), and the National Geographic Society (#7427-03, #7822-05). Brenda Wilkinson, BLM Archaeologist (Socorro Field Office) has provided consistent assistance and facilitated financial support for this fieldwork. In addition, my Research Assistantship with Andrew Duff at Washington State University was funded by the National Science Foundation grant (#BCS-054595).

A portion of the grants awarded to Andrew Duff funded my airfare to the Chicago Field Museum to study their collections of whole ceramic vessels, and Dr. Scott Demel, collections manager, made my visit enjoyable and productive. The New Mexico Archaeological Council (NMAC) generously awarded me a grant to fund the gas chromatography/mass spectrometry analyses, which were graciously performed on short notice by Dr. Mary Malainey of Brandon University, Manitoba. Additional protein residue analyses were conducted by Dr. Robert Yohe of the Laboratory of Archaeological Sciences at California State University-Bakersfield, and were funded through Dr. Duff's Bureau of Land Management grant. In addition, several key people aided my museum collections research including: Dr. Cynthia Bettison of Western New Mexico University Museum; Dr. David Phillips, Maxwell Museum of Anthropology, University of New Mexico, Albuquerque; and Dr. Melissa Powell, Museum of Indian Arts and Culture, Laboratory of Anthropology, Santa Fe.

Numerous friends and colleagues in Pullman and afar "talked shop" but also offered non-academic conversation and companionship that was key to surviving the stress of graduate school. Aaron Wright and Alissa Nauman collaborated on papers and shared lab time and data, and Darin McDougall spent long hours on lab work always offering a much-needed laugh.

I must thank Jeremy Carfi for moving cross-country and sharing a little house in Palouse with a cranky student. His dedication and affection encouraged me greatly. I am indebted to Janet and Walter Elkins for always being proud parents and offering their unending support and wisdom. They have the knack of always being right. I dedicate my professional and personal successes to them and to my siblings Julie, Judy, and John. To Dottie Sawyer, a wonderful grandmother and schoolteacher, for introducing me to archaeology and a passion for learning when I was very young.

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ABSTRACT

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December 2007

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Two great houses in west-central New Mexico, Cerro Pomo and Cox Ranch, are situated at Chaco's southern frontier and contain ceramic evidence for the co-residence of Mogollon and Pueblo groups. Brown ware is generally attributed to the Mogollon, whereas gray and red ware is attributed to the Pueblos. Mogollon Brown Ware dominates the assemblage, and bowls with smudged interiors are prevalent. In fact painted red ware bowls, common at contemporaneous sites to the north in traditional Pueblo territory, are comparatively rare at these sites. This study explores the possibility that smudged brown ware was used in place of red ware as serving bowls, a potential indicator of Mogollon historical practice. The distribution of smudged brown ware and red painted ware is documented, and the functional similarities between the two are explored using vessel size and sherd apparent porosity to measure the vessels' original function and raw material attributes. In addition, the possible function of these wares was directly measured with protein residue and gas chromatography/mass spectrometry analyses. The sherd size data indicate that painted red ware and brown smudged ware bowls were manufactured in similar sizes and therefore were functionally similar; however the whole vessel sizes of brown and red bowls are not statistically similar. Apparent porosity data varies slightly between brown and red ware bowls suggesting that although they could have served a similar purpose, they were manufactured from distinct clays. Similarly, the unrefired apparent porosity varies slightly

between brown and gray jars. These differences may relate to different vessel function, but they may also be within the known limits for cooking jars.

On this northern periphery of Mogollon territory, the regional spatial patterning in the distribution of red, gray, and brown wares indicates that the frequency of smudged brown ware generally increases from north to south. Furthermore, this distribution demonstrates that numerous sites in the Southern Cibola region exhibit a mixture of Mogollon and Pueblo ceramic traditions, indicating that ethnic co-residence was not unique to Cox Ranch and Cerro Pomo. Overall, it seems that the residents of sites in this transitional zone were placing higher value on smudged ware and choosing to use it rather than red ware. This technological difference could be signaling the expression of Mogollon ethnicity in the Southern Cibola region and the southern periphery of the Chacoan regional system.

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CHAPTER 1
FROM POTTERY TO PEOPLE

"This approach requires that we understand craftspeople as social actors rather than simply as products/bearers of culture or as acultural adaptive engineers and that we understand the production and use of objects as social activity" (Dietler and Herbich 1998:246).

The distribution of prehistoric ceramic styles has long been linked to specific ethnic groups and used to infer social organization, migration, material culture exchange, and ethnic co-residence in the American Southwest and throughout the world. Pottery, as an additive technology, is an ideal medium for studying the relationship between artifact style and identity because the finished form reveals the intentional steps involved in manufacture. These steps, or elements of technological style, can often be linked to the historical traditions and learning frameworks of the potter (Lechtman 1977; Pauketat 2001; Reid and Montgomery 1998).

I utilize the theoretical perspective of ceramic technological style to explain the mixture of distinct ceramic styles at sites located along the frontier of the traditional boundary between the Mogollon and Pueblo (Anasazi)[1] culture areas in west-central New Mexico and east-central Arizona. There is evidence for ethnic co-residence at these sites including the presence of both brown ware (traditionally associated with the Mogollon) and gray ware ceramics (Puebloan) in all site contexts. Both brown and gray ware ceramics are largely utilitarian, dominated by jar forms with both plain and corrugated exteriors, but they can be distinguished by paste color. In the project assemblage, neither of these wares is painted. In contrast to gray ware, brown ware exhibits more variation in corrugation type and pattern, and was manufactured in both bowl and jar forms. Brown ware bowls often have smudged interiors—an effect achieved in firing resulting in a shiny black surface. Brown and gray ceramics are visually and technologically

[1] Throughout, I use the culturally appropriate terms "Ancestral Puebloan," "Puebloan," or "Pueblos" in place of the more widely used term "Anasazi" for the same group of people, unless used in a direct quote.

different and made from different clays – all indicators of distinct choices being made by the potters during production.

Specifically, this study aims to assess the technology and distribution of Mogollon smudged brown ware bowls, emphasizing their potential use as ethnic markers within late Pueblo II-era Chacoan communities (ca. A.D. 1050-1150) that I argue were characterized by co-residence of Mogollon and Pueblo people.

Two communities in particular, Cox Ranch and Cerro Pomo Pueblos, provide the majority of the ceramic data for this study. These sites are located in west-central New Mexico, on the southern periphery of the regional system that was centered on Chaco Canyon, and just south of the modern pueblo of Zuni in the Southern Cibola Region (Figure 1).

Figure 1. Map of New Mexico Showing the Locations of the Southern Cibola Region, Chaco Canyon, Cox Ranch, and Cerro Pomo Pueblos (base map from www.lib.utexas.edu).

This area witnessed a dramatic increase in sites after A.D. 1000, and includes communities organized around great houses with many parallels to Chacoan buildings (Duff and Lekson 2006; Lekson 1996). The degree of influence on these sites from Chaco Canyon, however, is debatable. Residents of these great house sites on the southern boundary of the Chacoan regional system likely shared a "frontier experience" with loose ties to Chaco ideology (see Herr 2001). This common bond (Stein and Lekson 1992) may have served to foster integration of people with diverse backgrounds. However, the cultural identity of these people was likely negotiated closer to home, at the level of individual communities with ethnically diverse histories.

The ceramic types in the Southern Cibola Region are Cibola White Ware and White Mountain Red Ware which include black-painted and plain varieties, and plain gray and brown wares which include corrugated varieties (see Chapters 3, 4 and 7 for ceramic type discussion). Plain gray ware and red painted ware are attributed to the Pueblos, while brown ware is a hallmark attribute of Mogollon culture (Wheat 1955).

Even though Mogollon Brown Ware ceramics are found in many prehistoric sites of the Southwest, their distribution and technology are not well understood and are therefore important research topics. Brown ware is found in abundance at many central and southern New Mexico sites alongside lesser quantities of White Mountain Red Ware and Pueblo gray ware. White Mountain Red Ware exhibits thick red slip, buff to gray paste, and black painted designs on bowls and jars (Carlson 1970). It appears that in the Southern Cibola region, there is a substitution of Mogollon brown ware for White Mountain Red Ware, two ceramic types which are likely functionally equivalent.

Mogollon Brown Ware manufacture began as early as A.D. 400 and gained in popularity through time, continuing in assemblages as late as A.D. 1450 (Peckham 1990). Plain ware ceramics such as Mogollon Brown Ware and Pueblo gray ware exhibit a wide range of surface treatments and manufacture styles, including corrugation, incising, and punching, blurring the lines between style and function. Mogollon Smudged Brown Ware bowls are a specific example, exhibiting highly polished interiors with a black luster and both plain and corrugated exteriors. I argue that smudging on brown ware bowls served an important decorative function and was used to actively communicate Mogollon heritage and identity.

Analyses of the brown and gray cooking jars from the Cerro Pomo and Cox Ranch communities have been conducted to assess the similarities between vessel use, manufacture, and clay availability (Elkins, Duff, and Wright 2006a, b). The results of clay oxidation studies, measures of apparent porosity, and temper characterization indicate that brown and gray ware jars, though visibly and technologically different in clay type and manufacture, could have served similar functions. My current research asks whether these ceramic technological differences rooted in Mogollon and Pueblo traditions also translate specifically to brown smudged ware and White Mountain Red Ware painted bowls.

Mogollon Brown Ware dominates the Cox Ranch and Cerro Pomo community assemblages, and smudged brown ware may have been used at these sites in place of red painted ware as serving bowls, a potential indicator of historical practice (Elkins and Duff 2007). I hypothesize that in the southern Southwest, the frequency of smudged brown ware generally increases as one moves from north to south. The southern edge of this distribution corresponds with the northern periphery of Mogollon territory. In addition, to confirm that brown and red painted bowls were functionally similar, it must be demonstrated that both wares were manufactured in similar sizes for similar use. If this is true, it seems plausible that site residents in this transitional zone were placing higher value on brown smudged ware and choosing to use it rather than red painted bowls, presumably for serving foods. This preference could be signaling or expressing Mogollon ethnicity.

The technology and distribution of Mogollon brown smudged ceramics are the focus of this study; the goals of which are to explore the functional similarities between brown smudged and red painted bowls, to document the sub-regional distribution of these wares in east-central Arizona and west-central New Mexico, and to discuss the implications of these analyses for migration and social organization. In order to further explore the apparent similarity in red and brown ware vessel size, and to determine vessel function and raw material choice, I have collected the following data: vessel size as measured from whole vessels in museum collections and as estimated from sherds, and measures of apparent porosity and refired sherd color. In addition, protein residue analyses and characterization of fatty acids through Gas Chromatography/Mass Spectrometry were conducted as direct measures of vessel function.

The presentation of my research is organized as follows: Chapter 2 outlines the theoretical perspectives I use for explanation, including a discussion of technological style, agency and ethnicity, and vessel form and function. Chapter 3 provides a background to the culture history of the study area, defining the characteristics of the Mogollon and Ancestral Puebloan culture groups, and outlining ideas about the Chaco regional system and its influence on the Cox Ranch and Cerro Pomo Pueblo communities. Brief descriptions of Cox Ranch and Cerro Pomo are provided as an assessment of whether or not the residences of the Cox Ranch and Cerro Pomo communities were contemporaneous. Chapter 4 examines the distribution of ceramic types in the Southern Cibola region to evaluate whether there is spatial patterning in the distribution of characteristically Mogollon and Pueblo ceramic wares. Chapter 5 provides a description of my analysis methods. In Chapter 6, I outline a case study of ceramic technological style at Cox Ranch Pueblo that confirms the ethnic co-residence of Mogollon and Pueblo people. Chapter 7 provides an extensive background on Mogollon Smudged Brown Ware—the technique, its geographic distribution and chronology, inter-site provenience, a comparison with White Mountain Red Ware, and an assessment of whether smudging technology is stylistic or functional. Chapter 8 contains comparisons of brown smudged ware versus painted red ware vessel size and use, while Chapter 9 provides a summary of the study with conclusions and implications.

In sum, these analyses indicate a north-south cline in the proportions of Pueblo red painted and Mogollon brown ware. Similarly, Pueblo gray and Mogollon brown ware proportions exhibit a clear north-south cline. These ceramic distributions mirror the geographic extent of these two culture groups: Pueblo in the north and Mogollon in the south. In the project area, however, there appears to be a blending of these two ceramic assemblages with Mogollon material culture dominant. Mogollon brown smudged and Pueblo red painted bowls likely functioned similarly, but brown smudged bowls were preferred. I argue that this choice is linked to the practice of Mogollon potters with histories distinct from those of the Pueblos.

CHAPTER 2
CERAMICS AND IDEOLOGY

"After all, it is hard to imagine a single theoretical structure that could explain the meaning of symbols on a pot, the function of the symbols within the social/ideological system of a region, and why particular paints and firing techniques were used in the ceramic manufacture. Archaeologists may reasonably ask each of these questions, but they will require very different approaches to answer them." (Van Pool and Van Pool 2003:2).

This chapter outlines theory related to technological style, agency, and ethnicity, and vessel use and function that I use in this study. Even though each of these complex topics deserves in-depth explanation, I discuss them briefly here as they relate to my specific research questions. I argue that Mogollon brown smudged bowls in the Cox Ranch and Cerro Pomo communities were a decorative ceramic form used ubiquitously throughout the sites as serving bowls in domestic contexts. As such, they were an important means for communicating Mogollon ethnicity in the form of everyday emblemic style. The following section reviews approaches to determining vessel function and how this information can be applied to larger questions of social organization. The ceramic variability at Cox Ranch and Cerro Pomo cannot be strictly labeled as either functional or stylistic; both aspects are at play in the creation of any artifact. The interplay of style and function may in fact be demonstrated empirically (Brantingham 2007). An artifact's function is more than utilitarian; it is determined by how it performs in a particular society's technology (Sackett 1977; Skibo 1992).

Technological Style, Agency, and Ethnicity

To build a conceptual bridge from pots to people, we must understand how aspects of culture such as ethnicity may be expressed through artifacts. The following discussion highlights major contributions to understanding style in archaeology, calls for an integrative approach, and outlines my ideas as to how the ceramic styles of the prehistoric Mogollon people reinforce their cultural and historical identity.

The general concept of style is nebulous as it applies to material culture. As Hegmon (1992:517-518) noted in her review of archaeological research on style, there is no uniform theory of style. However, most researchers share two basic tenets: 1) style is a way of doing something, and 2) style involves choices among alternatives. I distinguish between active and passive conceptions of style. Active style implies that differing ceramic technology or design exists because of individual intent and choice on the part of potters, whereas passive style implies that these differences exist as part of the natural range of variation in pottery manufacture. Initially, style was considered to be a passive indicator of cultural affiliation and played a large part in the formulation of time-space systematics (i.e., culture areas, temporal phases and periods). Since the 1920s cultural-historical era in archaeology, the passive conception of style has underwritten the use of ceramic types for designating culture groups that are temporally and geographically bounded (see Kroeber 1916, Spier 1917). The assignment of types based on pottery decoration is still an integral, though flawed, system for assessing site dates and regional organization. More recently, researchers have focused more on the active aspects of style and its relationship to human behavior. But what exactly is style, and what can it reveal about the social phenomena that are otherwise unobservable?

According to agency-based theoretical approaches, style stems from individual choices made during the production process (e.g., Lechtman 1977). Even though the steps of pottery manufacture may become habitual, or largely unconscious, the choices potters make are contingent upon several factors, including social and historical context. Style is a means by which individuals express themselves and negotiate social strategies. Particular pottery styles can be linked to specific geographic regions or even individuals. Therefore, in agency-based studies, style is an active rather than passive property of archaeological artifacts.

Potters can intentionally use aspects of style such as ceramic vessel design, color, size, and shape to encode meaning that is intended for an audience. In other words, a particular painted pattern on a ceramic bowl can signal to its users that its maker is part of a particular group—it can signify identity. One of the first to suggest that style had an active function in culture as "information exchange" was Martin Wobst (1977). Wobst's information exchange theory asserts that people convey simple messages through style. In this model, unfamiliar people are involved in the exchange of information, and only simple messages can be efficiently exchanged between potter and user. On the other hand, according to Wiessner (1985), people in close social situations could also communicate information with more complex, ambiguous style. Hegmon (1992:521) asserts that material visible only in private is more likely to convey messages about ritual or belief systems, whereas highly visible material often signals group or ethnic boundaries. Wobst's (1977) information exchange theory was one of active style, but needed to be broadened to include more complex information exchange between individual human agents as well as groups. On this note, Margaret Conkey (1990:15) offered an early post-processual critique to style in which she supported "the view of material culture as an active, constitutive element of social practice."

Not only the artifacts, but the process that produces the artifacts is imbued with style (Lechtman and Merill 1977:5). This concept is referred to as technological style, and it is an effective means for understanding the subtle differences in pottery technologies which can in turn be linked to group norms or enculturation. Technological style refers to the production sequence which results from the decision-making process of an individual (Lechtman 1977; Mauss 1973; Pauketat 2001). Pottery is an additive technology and each step of the production process is encoded in the final product. The production process itself reveals decisions made by the artisans, and can provide clues to the nuances of individual manufacturing styles, which may be cultural or individual in origin (Lechtman 1977).

Ceramic production is a sequence, or a continuum of production decisions interspersed with formal steps. It can be likened to the operational sequence or *chaîne opératoire*, an "ordering of the technical domain expressed by choices" (Lemmonier 1986:171). These steps originate with the acquisition of the clay and continue until the ultimate discard of the product. Stages identifiable from the ceramic body consist of the type of clay used, addition of non-plastics, forming, shaping, firing atmosphere, rapidity of cooling, application of decoration and any post-manufacturing modifications (i.e., recycling, repair, re-use) (Lechtman 1977). At any point along the production continuum, the potter decides how he or she will proceed, and these decisions are evident in properties of the finished item, such as coil thickness, type of temper, indentation width and shaping method. At a larger scale, manufacturing choices may be largely unconscious or may be actively selected, either of which can reflect group identity or norms, learning frameworks, and technological change because the way a potter learns to make a pot will be evident in the properties of the finished form. Therefore, elements of a potter's enculturation in society are evidenced by their craft. These qualities make ceramics an ideal artifact class in which to study social learning and cultural transmission.

There is a significant behavioral and ideational component visible in pottery production. These components have a mental origin, either subconscious or intentional, reflected in the choices the potter makes during manufacture. Habitual actions like a potter's method of production are a form of practice, and they "may be second nature and beyond the realm of thoughtful reflection or planned and politicized" (Pauketat 2001:8). Thus, although pottery manufacture may be habitual and follow routine actions and subconscious decisions, it is dictated largely by tradition that is learned from social interaction. Shepard (1980) and Dietler and Herbich (1998) have suggested that the intergenerational transmission of technological practices is the basis of cultural tradition formation. Sackett (1990:73) refers to the spectrum of choices that have an equivalent end product as "isochrestic variation," and the particular variants are indicative of particular social environments. The key to his argument is that the choices that an artist makes that can result in the same functional end are particularly stylistic, are learned and socially transmitted, and are rooted in historical context (Sackett 1990:33). However, he stresses that the potter may either make these choices actively with intention or passively by motor habit.

Wiessner (1983, 1985, 1990) has played devil's advocate with respect to Sackett's concept of style, although her core ideas about how style is perpetuated are not so different from his. Wiessner (1983) defines two types of style: emblemic and assertive, resting the distinction on the style of groups and individuals, respectively. These concepts are perhaps better understood through their behavioral correlates, which MacDonald (1990) calls "protocol" and "panache." Protocol relates to a group level norm or ideal, while panache represents individual expression. The social realm is inherent in a production sequence because individuals learn their trade in a social world, as they learn from others in the social group. As a result, cultural preferences and practices constitute technological traditions.

Wiessner's (1985) point of contention with Sackett lies in the behavioral basis of style. She critiques Sackett for a passive view of style and states instead that "style is not acquired and developed through routine duplication of certain standard types, but through dynamic comparison of artifacts and corresponding social attributes of their makers" (Wiessner 1985:161). In her view, style is consciously created and manipulated. In Sackett's view, artifacts exhibit an ever-present latent style resulting from learning frameworks, but he does not deny that potters can actively use style as well. "The explanation I favor by no means denies the existence of iconographic signaling in the archaeological and ethnographic records" (Sackett 1985:157). Conkey (1989) reiterates that whether or not style is conscious or subconscious is unimportant; the "maps of social action" are still suggestive of strategies of social identity, which makes them attractive for my purposes here.

The issue of the artist's choice often becomes a point of contention between post-processual or agency-based views of style and those of evolutionary archaeology. It is important to briefly review the evolutionary literature on style to better understand the agency-based approach, and to offer ways in which the finer points of both can be incorporated into a single theoretical framework.

It has been argued that basic pottery form is merely a by-product of the intended function of the item (Dunnell 1978), whereas decorative attributes are thought to represent intentional expression or style (Wobst 1977). Early evolutionary approaches (Dunnell 1978) tended to focus on delineating processes of the generation and transmission of style rather than its use. Hill (1985:378) sees that the choice of selecting one style over another is based on the idea that one has a "perceived adaptive advantage." Dunnell (1978) defines elements of artifact style as neutral with respect to fitness, they will vary randomly in a population. Functional elements of artifacts, however, will "directly affect Darwinian fitness" (Dunnell 1978:199). Those who advocate evolutionary explanations of style criticize agency-based approaches for their inability to explain the underlying causal mechanisms for change in style. "The lack of explicitly rendered theory positing causal mechanisms means that it is very difficult to derive empirical consequences that can be used to evaluate particular interpretations" (Neiman 2003:75).

While this criticism may stand, it is also true that evolutionary approaches, as implemented prior to the last decade, have focused almost exclusively on the production and transmission of styles, rather than discussions of what style does or how it is used. This approach inherently moves decisions about behavior further away from the individual. It is centered on the idea that there are systems so basic in nature that individuals are powerless to divert them. However, those who use evolutionary approaches in archaeology (see Eerkins and Lipo 2005; McClure 2007) would argue that individual behavior is accounted for because it is precisely the variation in individual choices that results in change through time. Frameworks such as cultural inheritance theory take the historical context of a cultural trait into consideration because the frequency of that trait in a population depends partly on its frequency in the past (McClure 2007).

I do not mean to misconstrue evolutionary approaches to style as technologically determinist, meaning that they explain the progression of technology as linear. I argue that style is created, transmitted, *and* used by human actors, and that the use of style as part of an individual or group's social strategy is a vastly important research domain. A model considering all three of these elements of style will yield the most fruitful results. When emphasis is placed only on the adaptive nature of technology, artifacts are removed from the historical circumstances in which they were created, and questions about the behaviors that may have created them go unanswered (Dobres 2000). In a simplified example, an evolutionary approach would explain the rise of cooking pots with effective heating properties that allow for better food procurement as representing a "style" that spreads because it increases fitness. However, the spread of the particular "stylistic" pattern of corrugations on these same cooking pots would be unexplained. An agency-based approach to style may explain these stylistic elements as indicators of group enculturation or historical practice that is passed down over generations of subsequent potters. The split between evolutionary and agency-based approaches to artifact style is an essential tension in archaeological theory. By exploring the differences and similarities between the two, we can build a more robust integrative theory to explain how style is used and more importantly why it is such an important aspect of material culture.

My previous discussion of evolutionary approaches to style is mostly based on the early work of Dunnell (1978) and others who see a strict dichotomy between style and function, leaving no room for material culture that has style with "social function." However, many integrative theories that illustrate that evolutionary approaches need not be strictly functionalist are emerging in archaeology. Human intentionality and choice act as sources of variation *and* as mechanisms of selection (Brantingham 2007; Maschner and Mithen 1996:10). Ames (1996:121) sees points of articulation between concepts of style as described by dual inheritance theory and those of agency theory in which style is actively negotiated. Specifically, Sackett's (1977) "isochrestic variation" and Wiessner's (1990) concept of symbolic stylistic variation are seen as distinctions which help to explain how cultural selection is operating on style. Potters make stylistic choices in manufacture that are carried on by subsequent generations of potters linked by a common history.

Brantingham (2007) shows that the style-function dichotomy may not be warranted with a simulated model of the change in ceramic decoration frequencies through time in prehistoric Southwestern households. Using the Price equation, which allows one to make empirically-based predictions about the direction of evolutionary change in a system, Brantingham (2007:413) asks whether change in ceramic decoration is correlated with performance, utility, or payoff. Those attributes of decoration that are functional are payoff-correlated, and those that are stylistic are payoff-independent, where payoff is defined as the differential performance or utility of socially-learned behaviors. He finds that the rate of change in ceramic decoration frequency is the sum of the payoff-correlated and payoff-independent processes. In other words, style and function may not be mutually exclusive, combining in unanticipated ways to determine change through time.

Numerous case studies have employed null models to generate expectations for artifact variability, which are then compared to the archaeological record. Many of these studies are based on the work of Dunnell (1978), later operationalized by Neiman (1995), as they combine concepts of selectively neutral style with neutral evolution. This tests the null hypothesis that style is neutral and that stylistic variation is the product of drift. Studies by Shennan and Wilkinson (2001) and Kohler et al. (2004) both use null models based on Dunnell's fundamental dichotomy between style and function, and Neiman's neutral evolution to generate expectations. For example, these studies assume that style varies randomly (a selectively neutral trait), and ask how style will vary through space and time and how it will be transmitted within and between populations. Kohler et al. (2004) find that a neutral model predicts a greater degree of variability in ceramic style than is evident in the archaeological record at Burnt Mesa Pueblo, a late 1200s village on the Pajarito Plateau of New Mexico. Ceramic styles are less diverse than expected for a large population. From this, they infer that conformist transmission or frequency-dependent bias was taking place in which an individual selects the most common model to imitate, and that this was a tactic to help alleviate within-group issues of cooperation during village formation (Kohler et al. 2004:114). Kohler et al. (2004:109, 116) assert that using these methods does not necessarily entail subscribing to a clean distinction between style and function. In fact, decoration itself can have function. Agents are part of the equation in that they were able to use and mold conformist transmission according to their circumstances. Individual households at Burnt Mesa Pueblo were using ceramic style to actively signal their willingness to conform to the larger group.

While I agree that neutral evolution models form a useful heuristic tool for generating testable expectations and interpreting apparent patterns, I believe that the style-function dichotomy, as originally conceived, is problematic for explaining the transmission of style. These null models are meant to pinpoint the areas which need further explanation when the null hypothesis does not fit. I distinguish between agency-based approaches to style which see the cultural transmission of craft production as the result of human decision-making, and fundamental evolutionary approaches which see artifact style as varying randomly. However, current empirical models of artifact style and function (see Brantingham 2007) attempt to simultaneously weigh both neutral and selective components of style without favoring either. We can use both approaches to better explain both how style is used as a social strategy and how it is produced and transmitted.

In examining style as culturally inherited and acted upon by selective forces, we must keep in mind that human agents and human decisions are what drive cultural transmission. Dietler and Herbich's (1998:245) use of Bourdieu's concept of *habitus* "accounts for both structure and agency by showing how the two are mediated through practice; that is, both how practice is conditioned by structure and how it reshapes structure in the process of reproducing it." *Habitus* can be defined as a person's set of dispositions created by their role in society that generate patterned actions by which culture is reproduced. "Rather than seeing practice as predetermined by a static set of cultural concepts or structures (e.g., some sort of rigid mental template), *habitus* is a dynamic relational phenomenon which is both an historical product and agent" (Dietler and Herbich 1998:247). In sum, style is transmitted from one potter to another, either by direct teaching or observation, and this drives the selection of certain styles over others. A potter works within a flexible cultural framework that informs their decision-making but can also be changed by their actions.

Potters and Craft Learning in the Prehistoric Southwest

In order to discuss the importance of individual agents in the transmission of ceramic style, we must have some sense of who the potters were and how they learned their craft. Prehistoric women likely formed ceramic vessels based on ethnography of modern Southwestern pueblos, potter toolkits in burials, and images of potters (Crown 2007; Mills and Crown 1995; Moulard 1984). Men, however, may have participated in painting pots (Hegmon and Trevathan 1996); and men likely became increasingly involved in the entire process through time as pottery specialization became important (Arnold 1985; Mills 2000). In the modern pueblos, men often help to paint pottery made by their sisters, wives, or other relatives (Crown 2007). Cross-culturally, women tend to be most involved in pottery production (Nauman 2007). In the prehistoric Southwest, pottery was most likely produced informally at the household level by adult women who taught the craft to their children with close kin contributing labor.

If aspects of style are visible in artifact manufacture, it then becomes important to understand the learning frameworks that guide the way style is transmitted across generations or to new community members. Everyday practice, as well as technical skills such as pottery manufacture, are often enculturated in children by the larger social group. The learning of craft production can therefore be argued to be rooted in community dynamics, where individuals develop essential skills through participation, observation, and guided interaction (Minar and Crown 2001). Similarly, cultural inheritance theory distinguishes between horizontal (peer group), vertical (parent to offspring), and oblique (between generations, kin group) types of social learning and posits that children most often learn from their parents and other adult kin (Shennan 2002; Shennan and Steele 1999). Social learning is superior to individual learning as a source of adaptive information acquired at little cost (McClure 2007). Crafting may also be an integral part of constructing and reproducing social identity (Hodder 1982; Sassaman and Rudolphi 2001).

The early stages of learning a craft require direct conscious control and attention of the learner since motor skills do not become set until adulthood (Crown 2007). With repeated experience through time, manufacture often becomes habitual, reducing the role of conscious decision-making for the sake of efficiency (Schneider and Fisk 1982:122). Such automaticity may help explain the conservative nature of many habits of material culture production and pottery manufacture in particular (Arnold 1985:235-237; Gosselain 1998). Crown (2002) has demonstrated that the learning of ceramic production was an active process between Pueblo children and adults, where children are taught the preferences of potters within their kin group with regard to many of the stages of pottery manufacture. Therefore, children learn within a "community of practice" (Lave and Wegner 1991) and reproduce this context with the continuation of the traditions that they are taught. Crown (2007) reinforces the importance of the community of practice, demonstrating with whole vessel museum collections that prehistoric pottery manufacture was a collaborative effort with multiple potters working on the same pot at once, skilled potters reworking novice's vessels, and artists adding to existing vessels over time. Pottery-making was a communal activity reinforcing cooperation, shared knowledge, and the guided learning of children.

In summary, I have shown that the physical traits of pottery can be a source of information about a group's learning frameworks and social norms that are transmitted from generation to generation. A set of choices are available to a potter at the outset of manufacture and the results of these decisions are encoded in the fabric of the finished product. Although pottery manufacture may become habit, it is still the result of a specific learning process that occurred in a particular time and place. Our ability to detect differences in pottery manufacture, thus, can be used to infer the presence of different enculturated groups from which interpretations of their histories can then be made. Applying these points to my study of Mogollon and Pueblo technological traditions, we can see that Mogollon children would learn pottery manufacture from their close kin. These techniques would be encoded in their finished vessels through historical practice—a history which was distinctly Mogollon rather than Puebloan.

Style and Social Organization

I turn now to ways that style can be used to answer questions of social organization. How can an interpretive leap be made from the technological style of pottery to expressions of ethnicity? I use the complicated concept of ethnicity here as it specifically relates to a group's ceramic technology, equating ethnicity with historical practice. Building on my previous discussion of style, differences in pottery manufacture can be attributed to different learning frameworks and therefore different groups of people who may use style to signify their respective group identities. Increasing research into the technological style of utilitarian ceramic vessels has shown that characteristics of the pottery manufacturing process can be isolated in attributes such as coil thickness and width, and clay properties (e.g., Crown 1981; Duff and Nauman 2007; Nauman 2007; Neuzil 2005; see case study Chapter 5). Differences in these characteristics are linked to vessel function, clay source, and the learning frameworks of potters, grounded in different traditions of manufacture. If these traditions are spatially or geographically bounded, inferences can be made about migration and/or ethnic co-residence. Ceramic technology can help us determine whether or not a site's pottery was produced by co-residing migrant people with different backgrounds. For example, Reid and Montgomery (1998) argue that undecorated ceramic wares can be markers of ethnic difference at a small regional scale, based on ceramic data from sites in east-central Arizona. At Chodistaas (late A.D. 1200s) and Grasshopper Pueblos (A.D. 1300s), they find evidence of both local brown ware and non-local (northern) orange-gray ware ceramics. The orange-gray sherds are technologically and compositionally different than the brown sherds, having distinct color, thinner coils, and sand temper from a source at least ten miles away, indicating intra-regional population movement. Orange-gray pottery increases dramatically during the last years of occupation at Chodistaas Pueblo, but is completely replaced with local brown pottery at Grasshopper Pueblo within a few decades (Reid and Montgomery 1998). Therefore, differences in ceramic technology can help us to detect population movement over short distances. This is largely true because undecorated wares are generally made by their users and not widely traded, whereas decorated wares are often incorporated into larger-scale trade and interaction networks. In this way, we can use undecorated wares to help us distinguish between "the movement of pots and the movement of people" (Reid and Montgomery 1998:447).

At the Cox Ranch and Cerro Pomo communities, where Mogollon brown smudged bowls appear to be used more often than red painted bowls, I think several kinds of style communication are at play–namely isochrestism and emblemic style (Sackett 1990, Wiessner 1983). Sackett's (1990) isochrestic variation rests on the idea that artifacts are imbued with style that results from enculturation in a specific social group, which results in an artist making many choices during the manufacturing process (clay type, vessel shape, temper)—the key point being that these choices will all produce an equally viable product. I hypothesize that these points can be seen directly in the ceramic assemblages of Cox Ranch and Cerro Pomo where two distinct ceramic traditions are present: Mogollon Brown Ware and Puebloan Gray Ware. When compared to Puebloan gray utilitarian cooking jars at the same site, brown ware jars served the same function, but they are visually and technologically different, and were manufactured using different clays (see case study, Chapter 6). However, brown ware ceramics dominate the assemblage. In addition, the decorative technique of smudging is overwhelmingly used on brown bowls at these sites. It is possible that potters preferred brown-firing clays although there are equally viable choices available locally. I argue that this pattern is indicative of a ceramic tradition in which potters are preserving techniques that transmit clear conscious affiliation with Mogollon history. These hypothetical points will be evaluated with ceramic data from Cox Ranch and Cerro Pomo communities (see Chapters 6 through 9 for further discussion).

As we have seen, ceramic technological style can be linked to the historical traditions of specific groups of people, and from this information we can make inferences about inter- and intra-regional population movement and ethnic co-residence. Having described my views regarding cultural behavior in regards to artifact style, I now turn to the ways in which we can make meaningful interpretations about ceramic patterning–specifically by studying vessel form and function.

Vessel Form and Function

Style and function need not be a strict dichotomy: pottery form, like technology and decoration, can also be important to stylistic communication. Furthermore, particular pottery forms such as bowls or jars, can correlate with particular functions. If vessel form is related to vessel function, and if different activities were carried out at different sites, then different frequencies of vessel forms will be found at those sites (Plog 1980:18). So technological style can be embedded in the steps of the ceramic manufacturing process, but also in how the vessel was actually used.

In this study, I use both vessel size and the physical properties of clay to infer original vessel function from ceramic sherds. At Cox Ranch and Cerro Pomo, the dominant bowl type is brown smudged, which occurs much more frequently than red painted bowls. Therefore, I must establish a framework for determining the function of bowls themselves. But how can we observe the properties related to vessel function archaeologically? Prehistoric vessel function can be ascertained through ethnographic analogy, archaeological context of recovery, experimental studies, and the presence/absence and location of decoration (Shepard 1980). In the section that follows, I discuss how inferences about vessel function can be made from size and shape, physical design, artifact context, and ethnographic use-life studies; and how this information can be applied to questions of social organization.

Vessel Size and Shape

The functions of domestic pottery are strongly reflected in their size and shape (Smith 1985:254). The best predictors for use from size are 1) relative openness of the vessel profile, 2) rim diameter, and 3) volume (Smith 1988). However, in archaeology, vessel size measures are often used as an unquestioned proxy for vessel function. This is often reasonable in Southwestern archaeology because the number of vessel forms is limited. These distinctions can be straightforward with whole vessels, but less so with sherds–the common medium available to archaeologists. A shallow, wide-based pot is interpreted as a serving bowl, whereas a tallnecked pot with a restricted opening is a storage jar. These lines are often blurred, however, as there are tall-sided bowls and wide-mouthed jars. Terms such as cooking pot and storage jar have considerable overlap. Moreover, ethnographic accounts have shown that the same vessel form can be used for a variety of different tasks depending on need (Miller 1985). The same vessel may be used to carry water and to prepare food. Pots could be appropriately thought of as multi-task tools (Braun 1983).

Based on the assumption that vessel form relates to function, we can make some inferences about the uses of bowls in contrast to jars. Bowls tend to be low-walled for accessibility and visibility of the food. A shallow, unrestricted bowl or dish permits immediate access whereas a narrow-necked jar is difficult to reach into. There is some evidence that bowls are conducive to exchange and transport because they weigh less and can be easily stacked or nested for carrying (Whittlesey 1974:108). In addition, use-life studies show that smaller, easily transported pots such as serving vessels and water jars are likely to break often because they are used and moved often, sometimes daily (Varien 1999; Varien and Mills 1997). Food bowls last about 36 months on average, whereas large jars last about 72 months (Graves 1985:23). Because serving bowls are important and valuable in many different contexts and break relatively frequently, they were likely a priority in ceramic production. These examples demonstrate that we can gain much information about a vessel's use simply from its form.

Serving bowls can be important indicators of both everyday and specialized activities at a site. Because pottery is the principal accessory to food production and consumption, it is therefore related to many of the taboos and rituals associated with food in numerous cultures (Orton et al. 1993:227). Ceramic vessels, especially those used for serving and eating food, tend to vary greatly in size depending on the volume of food prepared and served, the size of the serviced social group, and the variety of food-processing tasks taking place (Blitz 1993; Bray 2003; Henrickson and McDonald 1983). Therefore, consistently large vessel size is often interpreted as an indicator of ceremonial feasting or a show of status. For example, Blinman (1989) finds that ritual structures at a few large late Pueblo I sites in Southwest Colorado contain high numbers of large serving bowls, many of which are non-local, as well as excess bowl breakage indicating food consumption. He interprets this pattern as potluck feasting, where people are bringing food and vessels into the site to participate in ritual (Blinman 1989). In a similar example, Spielmann (1998:256, Table 13.1) indicates that painted bowl sizes averaging 21 cm in diameter in the Rio Grande were likely used as food serving bowls for a small number of people, such as a single household. She cites the presence of larger bowls (nearly 30 cm in diameter) later in time as evidence of communal feasting. Similarly, in her study of Salado Polychrome, Crown (1994) finds a preponderance of small polychrome bowls averaging 19 cm in diameter. She relates this pattern to an emphasis on the single-household domestic realm. As considered below, the sizes of whole brown smudged bowls in my sample are largely consistent with these smaller household-sized vessels which average about 20 cm in diameter. This would seem to indicate household production and use.

Vessel Design

The design characteristics of a pottery vessel are directly related to its function. Each vessel's suitability for a particular task depends on its design, in an engineering and artistic sense (Rice 1987:211). Pottery production involves real-life choices that may be rational, but are not always clear-cut for the potter since vessel use-life is somewhat dependent on its manufacture. A potter must consider the intended use of the vessel, as this will affect its size, shape, thickness, and surface finish.

The broad uses of pottery containers may include transport, storage, and/or food preparation. These uses put certain demands on the vessels themselves for capacity, stability, accessibility of contents, and ease of transport. Furthermore, use factors including whether the pot contents are liquid, dry or hold hot or cold foods, how long and often the containers are used, and distance transported relate to vessel design. The physical attributes of a vessel are important, especially if it will be used for cooking, as they can improve a vessel's strength against breakage caused by excessive heating, a property known as thermal stress resistance (Steponaitis 1984).

The problems of thermal stress can be reduced by manipulating three factors: the shape of the vessel, the porosity of the fabric, and the mineral inclusions in the clay (Rye 1981). Heat stress is obviously a factor for cooking jars, but it is also important for bowls which may carry hot foods and liquids. Thinner walls tend to conduct heat better, and increased porosity (space or pores in the clay wall) is better because it provides elasticity in the clay body that allows it to expand when heated without cracking (Rice 1987:230). The permeability or susceptibility to moisture can be reduced with interior surface treatment such as a glaze, slip or burnishing.

The decorative styles of pottery can also serve varied functions. The various decorative fields on both bowls and jars may be painted with different designs (Amsden 1936; Bunzel 1972; Plog 1980). The choice of design attributes by potters appears to be contingent on the vessel form, since designs used on bowls tend not to be similarly used on jars. As we have seen, the dichotomy between utilitarian and decorative pottery is not always valid. "Even pottery for cooking and serving food may also function in display" (Rice 1987:210). In Peru, for example, the Shipibo manufacture large pots solely for brewing and serving manioc beer (DeBoer and Lathrop 1979).

Ethnographic Use-Life Studies

Archaeological interpretations of vessel use and function can be ambiguous without ethnographic correlates for comparison. Ethnoarchaeological studies are often most successful at making headway in observations of pottery use, because they can take into account intended versus actual function (Skibo 1992). Studies of use-modification and use-wear on vessels can be very useful to archaeologists studying vessel form. Measurable surface modification can include sooting on cooking pots, the application of resins to improve cooking properties, and patterns of surface abrasion from stirring, transport, etc. (Longacre 1991:101).

There is little ethnographic information to be found specifically regarding the use of serving bowls or the importance of interior designs on bowls. However, in a pottery census of 10 communities, Rice (1987:295-297, Table 9.4) finds a large range in the composition of household assemblages. Serving vessels were relatively rare, accounting for only 4.3% of the total. However, three of the communities had no ceramic serving vessels, likely using other types of containers, and the Shipibo of Peru had an excess of bowls due to a culturally prescribed practice of hospitality for guests at meals (Rice 1987:295). This highlights the point that cooking and storage are common activities that have to be carried out in all households, but serving is much more variable and may depend on local tradition.

Vessel Use and Social Organization

Researchers have used both the distribution of general vessel types (jar, bowl) and sizes to infer social organization. Domestic contexts are expected to represent the most diverse set of activities and thus have the greatest range of vessel sizes, whereas specialized activities will be less diverse and should have a more restricted range of sizes (Blitz 1993:85). Standardization is more often recorded in the replication of containers for religious activities (Hardin 1991:66).

Ceremonial or special-use pottery is often found in smaller amounts and exhibits more labor-intensive craftsmanship.

I have discussed examples of the information available to archaeologists in determining vessel use and function. However, another important question is whether or not potters themselves place importance on the roles their pots play and what this may say about group affiliation. Potters may have their own assumptions about ceramic variability and an "ideal" type for the vessel's use. In her ethnographic study of Zuni potters, Hardin (1991:65) used a questionnaire that asked Zuni potters to rank a set of photographs of ethnographic Zuni vessels from the Smithsonian from "most to least Zuni." She found that most vessels were recognized as examples of specific types and placed within their culturally defined contexts of use. All of the participants ranked the vessels uniformly. Hardin (1991:3) concludes that "the Zuni possess an indigenous theory of ceramic variability, according to which explicit notions of context and appropriate form determine what a potter makes." Many potters obviously recognize the difference between their community's ceramic tradition and those of other areas, but this implies a deeper notion of an ideal type. In several studies at Zuni Pueblo (Bunzel 1929; Hardin 1983, 1991), when examples and photos of ancient and contemporary pottery were shown to participants, they were either accepted as Zuni or identified with another pueblo. There was a general concern with the correctness and distinctness of Zuni decorations, and offending attributes were singled out, indicating that a conscious boundary between traditions was present. This may indicate that the link between learned craft production and ethnicity runs very deep.

In sum, highly visible ceramic variation, of whatever kind, may hold important information about significant social and political boundaries (Longacre 1981:110). Therefore it becomes the archaeologist's task to reveal patterning in the prevalence, distribution, and kinds of pottery present at a site. Specifically, inferences about vessel form and function allow for a descriptive and predictive framework of explanation. Again, these principles are directly relevant to the current study because I use this framework to compare brown smudged and red painted serving bowls. Attributes I examine include size and intended function based on clay properties such as thickness and porosity–factors that influence a vessel's susceptibility to heat stress (see Chapter 5 for an in-depth discussion of these methods).

In this chapter, I have demonstrated that the symbolic nature of pottery includes the process of its manufacture, but extends beyond the way a pot is built or its form and function. Pots transmit information about their producer, owner, or user, such as status, religion, social conflict, or tribal affiliation. This information is transmitted through technological style, the steps in the manufacture process that involve choices among equally viable alternatives. These individual choices are dependent upon social and historical context and are transmitted from one potter to another as enculturated learning frameworks. Observed differences in the physical attributes of finished pottery can lead to hypotheses regarding processes that affect social organization such as migration and ethnic co-residence. In sum, pottery is part of a "material culture language" for communication of information between individuals and groups (Hodder 1986). Next, I turn to a discussion of cultural context and identity to understand how the technological style of ceramic vessels may signal ethnicity or group affiliation within the larger realm of prehistoric Southwestern society.

CHAPTER 3
CULTURAL CONTEXT AND IDENTITY: CENTRAL TO CHACO OR CLOSE TO HOME?

"Chaco was a combined set of ideas that were similar enough to create observable patterns but held by enough different people to manifest variation" (Toll 2006:148).

This chapter provides a cultural-historical background for west-central New Mexico and east-central Arizona. The sites that are the focus of this study—Cerro Pomo and Cox Ranch Pueblos—are first placed within the Ancestral Pueblo and Mogollon culture framework and the larger "Chacoan regional system" which flourished between A.D. 1050 and 1150. Then, I specifically discuss the Southern Cibola region and Cerro Pomo and Cox Ranch pueblos, from which my ceramic data are derived.

The nature and extent of the Chacoan regional system, specifically Chaco Canyon's position as a powerful center and its potential involvement in the social organization of many "outlier" sites, is widely debated. The focus of this analysis—Cox Ranch and Cerro Pomo—are large habitation sites dating to the late Pueblo II period (A.D. 1050-1130), and they are termed Chacoan because they contain characteristic great house architecture—large habitation structures with distinct masonry styles. They are located in the Southern Cibola region, an area that is on the far southern boundary of a regional system centered on Chaco Canyon in northern New Mexico (Duff and Schachner 2007: Figures 1 and 2). I argue that the Cox Ranch and Cerro Pomo communities had ideological ties to Chaco Canyon, as is evident in architectural styles, but few material culture ties. The ceramic assemblages suggest Mogollon and Pueblo ethnic co-residence, but are dominated by southern-derived Mogollon traits rather than those of Chaco or the Ancestral Pueblos to the north. Cox Ranch and Cerro Pomo better fit the description of "frontier communities" (Herr 2001) characterized by localized material culture traditions, rather than part of the Chaco regional system. The critical period of population growth and migration to the Southern Cibola area between A.D. 1000 and 1150 was one of “differentiation” (Cordell and Gummerman 1989:10) in which the complex regional system of Chaco had major influence, but also in which far outlying sites dealt with social organization on a local scale. To an increasing degree, sites on the far edges of the regional system became more autonomous and culturally distinct. Migration and the resulting social pressures were likely a catalyst for increased expression of Mogollon identity. The Chacoan regional system had far-reaching but diverse impacts on a large area. With increasing distance from the core of influence at Chaco Canyon, these effects appear to have been more indirect. More autonomous sites like Cox Ranch and Cerro Pomo may have incorporated Chacoan ideology on a small scale, but only had loose or indirect ties to the regional system.

In the discussion that follows, I describe the elements of the “Chaco phenomenon” working from Chaco Canyon proper to outlying great houses, the Chaco regional system and finally to explanatory models that account for its operation, function, and downfall.

Chaco Canyon

The Chaco era began as early as A.D. 860 with initial great house construction in Chaco Canyon, the center of a complex group of large sites in the San Juan Basin of northwest New Mexico, which arguably contains some of the most impressive monumental architecture in the prehistoric Southwest. The core area of Chaco Canyon proper only measures 16.1 km^2, but includes fourteen large great houses and numerous “small house sites” (Cordell 1997:310). Within the canyon, “residents expended almost unbelievable human energy to create a cultural landscape of epic proportions, a truly enduring architectural masterpiece” (Judge 2004:1). The feats of engineering include large multistory great houses, large subterranean ritual structures or great kivas, and extensive road systems. Chaco Canyon was a “central place” whose influence permeated the prehistoric Pueblo world and still remains prominent in the histories of the Pueblo and Navajo people (Doyel 2002).

Great houses within the canyon were up to five stories high and contained as many as 650 rooms (Doyel 2002). These structures were built to last, exhibiting extensive planning with large room size (25-54 m^2), associated enclosed plaza space and great kivas as large as 19 m in diameter (Cordell 1997). The great house walls exhibit distinctive core-and-veneer banded masonry. Great houses in Chaco Canyon itself, such as Pueblo Bonito, have been interpreted as places of ritual based on ritual artifact and avifauna assemblages (Durand 2003), absence of domestic features such as hearths, midden assemblages representing periodic dumping events rather than regular domestic refuse accumulation (Toll 2001), and small resident populations (Bernardini 1999; Windes 1987). Lekson et al. (2006) interpret great houses in Chaco Canyon as either warehouses for food storage or elite residences that may have had dual ceremonial functions. Mills (2002), however, does not see evidence for status and hierarchy (other than a few unusual burials), social ranking, limited access to long-distance goods, or means of controlling the staple economy in great houses.

Small house sites are also found in Chaco Canyon, and are in direct contrast to great houses. They are far more numerous, typically single-story, and contain about 16 small rooms associated with small kivas that are incorporated into the roomblocks (Cordell 1997; Vivian 1990). The structure walls exhibit various types of construction. Vivian (1990) has proposed that the differences in small and great houses were the result of two distinct ethnic groups living at Chaco Canyon. Those living in great houses had dualistically-based leadership in a rotating sequential hierarchy, and those living in small houses had more lineage-based leadership (Mills 2002).

There was a dramatic increase in construction in Chaco Canyon beginning about A.D. 1020 (Kintigh 2003; Windes and Ford 1996), when the largest great houses such as Pueblo Bonito were completed. Chacoan sites also appear in large numbers at great distances outside of the canyon during this time. The decline of Chaco Canyon proper as a central place is generally listed as A.D. 1150, though some extend it until A.D. 1300 (Lekson 1999). Now that we have a brief basis for understanding Chaco itself, it is imperative to move outside the canyon to examine similar sites and assess the degree to which they fit the "Chacoan" pattern.

Chacoan "Outliers"

The "Chaco phenomenon" was not restricted to Chaco Canyon; more than 225 possible great houses, sometimes termed "outliers," have been identified throughout the Four Corners region, extending into the southern reaches of Arizona and New Mexico (Figure 2; Kantner 2004:73). There has been a terminology shift in the literature on Chaco archaeology from "outliers" to the more general term "great house" to describe sites with Chacoan features, largely because of the uncertainty of direct relationships to Chaco Canyon (Kantner and Mahoney 2000; Mills 2002; Wilcox 1993). These great houses are connected to Chaco by similar architectural styles and the presence of "Chacoan" features such as roads and great kivas. These similarities may indicate a shared worldview, possible trade networks and/or sociopolitical alliances.

How do great houses outside of Chaco Canyon compare to those "classic" examples in the canyon? There is much disagreement on the interpretation of Chaco social organization, especially as it pertains to outlying great house sites, including the basic definition of a great house. The nature of Chacoan great houses is a mystery because they tend to exhibit great variability in size and architectural style, often adhering only loosely to classic Chaco attributes (Duff 2005:12; Van Dyke 2003). Moreover, many outlying great houses appear to have been more residential than ritual. However, there is remarkable variability in construction types at single buildings in Chaco Canyon as well, such as Pueblo Bonito. "Architectural variability within the canyon equals or perhaps exceeds architectural variability within great houses in the larger Chaco region" (Lekson et al. 2006:70). So our definition of Chacoan attributes itself may contain considerable variability.

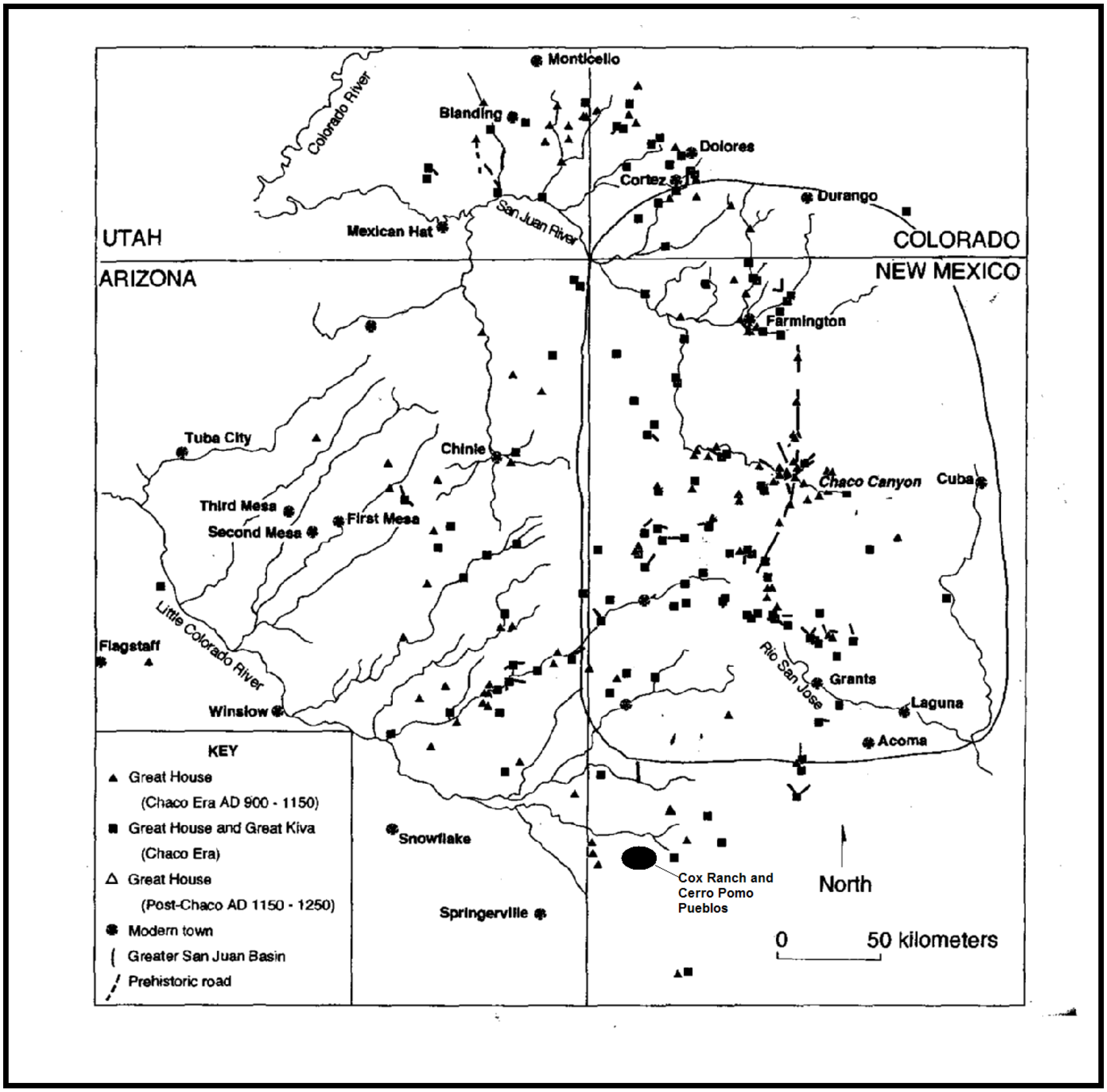


Figure 2. Chacoan Great House Sites Outside of Chaco Canyon (based on the presence of core-and-veneer masonry, multiple stories, and blocked-in kivas, from Kantner and Kintigh 2006:Figure 5.1).

Cox Ranch and Cerro Pomo Pueblos, in particular, possess what could be termed great house architecture with banded core-and-veneer masonry, but this Chacoan attribute is not ubiquitous throughout all areas of the great houses themselves. Kantner (2003) notes that no great house outside Chaco Canyon proper has all of the “classic” Chacoan features.

The community pattern of great house sites is determined largely by the presence of Chacoan style attributes. Hallmarks of Chacoan style include large room size, above-ground blocked-in kivas, earthen berms, public space, and banded core-and-veneer masonry (Duff 2005; Kintigh 2003; Powers et al. 1983). In addition, the presence of roads and great kivas may help to identify Chacoan sites, but alone they are insufficient criteria (Mills 2002).

In the loosest sense, a structure is designated a great house if it is larger in size relative to contemporary sites nearby. A distinct Chacoan settlement pattern has been proposed by Lekson (1991) with “big bumps” on the landscape signifying great houses, and surrounding clusters of “little bumps” or smaller unit pueblos signifying related households. A community in this sense consists of a cluster of unit pueblos surrounding a great house (“big bump”) and possibly a great kiva as the focal points. Often, there is significant distance between these communities and Gilpin (2003) finds that the settlement clusters are at least thirty times as densely packed as the surrounding area. Membership within one of these particular aggregations must have been meaningful because it entailed regular interaction with neighbors and possibly a shared sense of identity (Kantner and Kintigh 2006).

The Chaco Regional System

What *was* Chaco in the sense of a system if we include all of the surrounding communities that exhibit Chacoan attributes (a growing and complex list)? When taken together, all of the outlying communities with great houses are referred to as the “Chaco Regional

System," and it may have had ideological and possibly political hold over a large area of the Colorado Plateau and possibly beyond (see Figure 2).

Many sites are described as having Chacoan-style architecture, but it becomes problematic to address issues of community in relation to those sites. For instance, what factors determine whether a great house was central to a community? Often, but not always, there are smaller roomblocks associated with a great house as well as dispersed surrounding sites that appear to be contemporaneous. It is possible that Chacoan architectural complexes were not associated with a community, as some researchers have noted isolated great houses (Gilpin 2003; Powers et al. 1983). Can the elements of a system be defined and do Chacoan outliers fit the definition? Kantner (2003:207) lists the criteria for a system as regular interaction, interdependency, and unification. He concludes that only a small portion of the Chaco World—that closest to Chaco Canyon—fits the profile of a systemic entity. Foremost, regular interaction would entail extensive resource exchange that is not evidenced in the majority of Chacoan outliers. Studies of lithics, fauna, and ceramics have shown that material was moving into Chaco Canyon from outliers at different frequencies through time, but little material has been identified as flowing back out from the canyon (Kantner and Kintigh 2006:166). Furthermore, Chaco's poor geographic location offered no viable goods to other sites in better environments, ruling out reciprocal exchange with any advantage for the outliers. Chaco itself appears to have received utilitarian material from nearby communities; whereas rare items such as turquoise, shell, and copper bells were brought in from much farther. It also appears that the vast majority of ceramics in outlying Chacoan communities was produced locally and traded with immediately surrounding areas (Gilpin and Purcell 2000; Kantner et al. 2000; Van Dyke 1997). More likely, the Chaco regional system was a two-way system rather than a regional one, in which "Chaco saw outlying areas as a source of needed material, and inhabitants of these areas saw Chaco as the center of a powerful belief system" (Kantner and Kintigh 2006:175). The following section discusses some of the many explicit models for social organization in Chaco Canyon and beyond.

Explanatory Models for the Chaco Regional System

Chaco Canyon was a group of conspicuously large sites in a marginal desert environment that today is "subject to dramatic temperature extremes and devoid of trees and year-round running water" and had a wide-reaching relationship with the larger region (Lister and Lister 1981). How, then, was such a complex system organized? Furthermore, what kind of leadership structure could wield influence over a large surrounding area? Several models have been formulated to explain the nature of Chaco's influence, positing religion, politics, and economics as driving forces.

Most Chaco scholars posit that leadership in the canyon and outlying communities was based on ritual authority. An early example is the "pilgrimage fair model" (Judge 1989; Toll 1985) in which surrounding San Juan Basin populations made religious pilgrimages to Chaco Canyon, a ceremonial center with a small permanent population and ritual "elite." In a more recent but related model, Renfrew (2001) sees Chaco as a "location of high devotional expression" or ritual center that integrated surrounding populations by functioning as a place of religious pilgrimage. In this model, the production and consumption of goods is nonmaterial, rather the ideational/devotional significance of the great houses is the center of the system. This designates Chaco as an essentially egalitarian society. Mills (2002) distinguishes other ritual center models based on leadership strategy; those who obtained followers through competitive action (Van Dyke 1999), and those with multiple ritual leaders organized hierarchically who cooperatively managed labor (Saitta 1999).

In contrast, several models see Chaco as a state with hierarchical political organization (LeBlanc 1999; Lekson 2006; Wilcox 1993). Wilcox (1993) places Chaco at the center of a militaristic network of control over neighboring populations, obtaining tribute through force and outright violence. Tribute would have been collected by large "armies" of warriors who traveled to outlying sites by way of the Chacoan road system and set up barracks at sites like Chimney Rock Pueblo. Lekson (2006) also sees Chaco as an elite central government with spiritual as well as political power based on evidence of high-status burials, elite residences (great houses), and regional primacy (central to the Chaco Regional System). He rejects the idea of Chaco as a ritual center as too simplistic and argues that the modern Pueblo social system is a reaction against the unnatural domination that was caused by Chaco (Lekson 2006:29).

Models which posit Chaco as an elite center are problematic because there is little direct evidence of violence, elite leadership, or differentiation between the residents of Chaco Canyon and outlying communities during the Chaco period to lend support to these arguments. Furthermore, most demographic estimates for Chaco Canyon are conservative with peak populations of 3,000 people contrasting with estimates of 55,000 people for the surrounding San Juan Basin (Dean et al. 1994). Combined with the lack of other evidence, it does not seem possible that such a small number of elite at Chaco could hold significant power over a large area, though they may have been present and powerful within a more restricted area.

Those models which posit economics as the means of organization at Chaco include Sebastian (1992) and Wills (2000). Sebastian (1992) reasons that Chaco had competitive leaders who maintained their authority through control of surplus food production during periods of favorable climate. In her simulated model, the peaks of construction at Chaco did not always correlate with peak precipitation. Therefore, leaders were able to encourage growth regardless of environmental conditions because their power drew on more than economic sources (Mills 2002). Wills (2002) proposes that Chaco leadership was cooperative and organized at the lineage or residential group level. This leadership revolved around organized labor for construction episodes in the canyon that likely drew on populations from surrounding areas.

A model which seems to allow for variability involving Chaco and distant communities is that of peer-polity interaction and symbolic entrainment (Durand 2003; Kantner 1996; Kintigh 1994; Renfrew 1986). In peer-polity interaction models, communities do not have dominant/subordinate relationships; rather relationships are based on displays of wealth or power such as ritual or monumental construction by aspiring leaders to gain status. Less powerful communities voluntarily adopt a symbolic system because it "carries with it an assurance and prestige which a less developed and less elaborate system may not share" (Renfrew 1986:8). Therefore, there are power differentials at play, but without direct coercion. Emulation does not necessarily have to be competitive. Chaco Canyon contained impressive monumental architecture that represented a highly visible and far-reaching ideology. The adoption of this ideology was attractive to surrounding communities because it brought with it the promise of shared participation in a revered system, and this may well have involved periodic pilgrimage.

I argue for a symbolic purpose to Chaco centered on individual community-based ritual and voluntary participation rather than one of direct governance or control, though loosely shared social organization was likely an indirect result. I disagree with the dichotomy between ritual authority and economic or political authority that is often attributed to Chacoan political systems. Furthermore, discussing Chaco society in either/or terms of hierarchical and egalitarian misses the point that modern and past pueblo societies may have embodied both kinds of social relations (McGuire and Saitta 1996:198). Judge and Cordell (2006:207) assert that in modern Puebloan society priests may wield authority in both ritual and political realms. Many modern Pueblo governments are not based on kinship ties, but on a system of moieties that successfully integrate people with different cultural backgrounds because it encourages broad ritual participation (Judge and Cordell 2006:197). Ritual ties cut across community lines and ritual knowledge, though secretive in most circles, is exchanged among members of different pueblos that share the same ritual society. Furthermore, individual villages in pueblos today are politically autonomous and economically independent.

The evidence seems to indicate that the Chaco world was not well-integrated politically or economically, and that a shared cultural identity was present in communities to varying degrees. Variability in Chacoan sites may indicate emulation of a far-reaching Chacoan ideology and sense of style, rather than a direct connection with Chaco Canyon. I believe that the further away from "downtown" Chaco one gets, the less direct influence there is on outlying sites. The most impressive Chaco great houses are found in close proximity to the canyon (Kantner and Kintigh 2006:176). Van Dyke (2003) showed that when you move beyond the boundaries of the San Juan Basin, great kivas become more prominent, as do earthworks and roadways, suggesting non-canyon communities had their own forms of monumental architecture and were independent from Chaco proper.

Similarly, in a survey of Mogollon Rim communities dating to the A.D. 1100s in the Silver Creek area of Arizona, Herr (2001) finds that clusters of roomblocks were associated with a Chaco-like great kiva. These kivas are different from the typical Chacoan great kiva, however, in that they lack extensive labor investment and are therefore less formal. She attributes this pattern to a “frontier experience” in which northern migrants with a sense of the Chaco architectural pattern moved to the Silver Creek area and built their own style of kiva that provided a familiar cultural symbol and helped to foster group identity (Herr 2001:93). Ritual structures are likely very important to a community, therefore the act of joining together in construction would have been important for integration. Features such as great kivas are common in Mogollon sites throughout the region, and may have served to bring members of dispersed communities and of different cultural traditions together in a culturally neutral, unthreatening communal setting (Anyon 1984; Reid 1989).

The broad similarities in great house architecture throughout the San Juan Basin suggest that the form is not the product of independent invention, but possesses enough variability to represent local variations on a theme. The pattern may represent “the spread of an iconic style, affiliation with the Chaco package—and not everyone was a member” (Van Dyke 2003:137). This is similar to other religious traditions with powerful spiritual centers that experienced a degradation in symbolic fidelity and sociopolitical allegiance as distance from the center increased and as time passed (Kantner and Kintigh 2006:177, 180).

A shared Chacoan ideology may have helped to foster social cohesion during times of stress and increased migration; however it was not all-encompassing or completely integrative. In the Southern Cibola region, there appear to be in-migrations of northern people during Pueblo II (early A.D. 1000s) that were likely part of a larger Pueblo II expansion. These are more visible further south in southwest New Mexico’s Mogollon highlands, where radical changes in site and room counts lend justification to migration from the north (Haury 1988; Oakes 1999).

Great house settlements such as Cox Ranch and Cerro Pomo Pueblos are also founded at about the same time as this expansion, and connections between these migrations and central

Chaco are likely (Duff and Lekson 2006:328). Because it seems unlikely that the residents of sites on the Chaco frontier had distinctly Chacoan identities, changes in social structure likely occurred as the result of in-migration of northerners. But what was the nature of Cox Ranch and Cerro Pomo's cultural identity that seems to be closer to home rather than centered on Chaco? I now turn to this question.

Mogollon and Ancestral Puebloan Culture History

Now that I have outlined the basic structure of the Chaco regional system, I turn to a discussion of cultural identity at a local scale which entails an outline of Mogollon and Pueblo culture history. The study area is termed the Southern Cibola region of west-central New Mexico (Figure 3). It is centered on the Zuni reservation extending north to the Rio Puerco River near Gallup, New Mexico; west to St. Johns Arizona and the southern reaches of the Upper

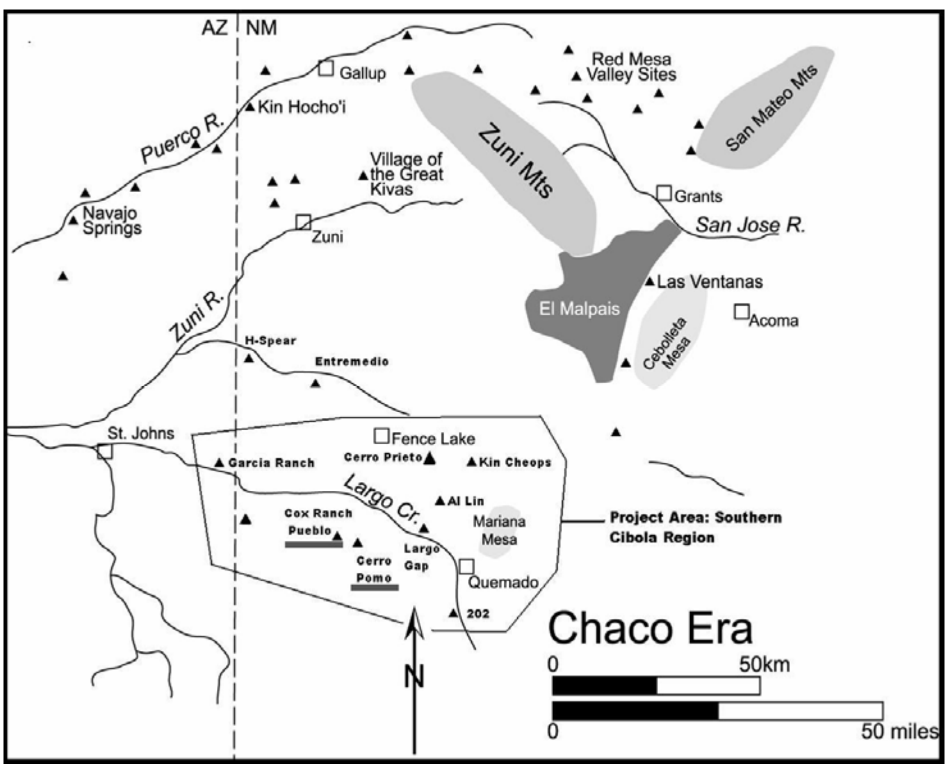


Figure 3. Chaco-Era Sites in the Southern Cibola Region Showing the Location of Cox Ranch and Cerro Pomo Pueblos (Duff 2005).

Little Colorado River; east to Cebolleta Mesa and Mariana Mesa, and south to the Mogollon Rim (Duff 2005:3).

The Southern Cibola region exhibits a blending of two main cultural influences: that of the Mogollon and of the Ancestral Pueblos, particularly during the late Pueblo II and early Pueblo III periods (A.D. 900-1150), a pattern that increases through time. Emil Haury (1936) first coined the term "Mogollon" to describe the occupants of two sites in southwestern New Mexico: Mogollon Village and the Harris site. The material culture of these sites was originally thought to have elements related to the Hohokam and the Pueblo Basketmaker; however excavations revealed the consistent association of plain brown ware pottery and deep pit houses that did not fit with either (Reid and Whittlesey 2005:51). Therefore, it was regarded as "the manifestation of a third and fundamental group which has been called the Mogollon Culture" (Haury 1936:2-3).

The Mogollon tradition roughly extends from eastern New Mexico near Las Cruces west to central Arizona near the Verde River, and from the Little Colorado River area in the north, south into Sonora Mexico (Cordell 1997:202) (Figure 4). This large territory borders the Ancestral Puebloan area to the north and contains varied terrain including the Mogollon Mountains, a source of volcanic temper in some Mogollon brown wares. The Mogollon "homeland" spans the Mogollon Rim of Arizona, the northern limit of the Mogollon Mountains and a transitional zone running diagonally between the basin and range deserts to the south and the Colorado Plateau to the north (Reid 1989:69).

In its simplest terms, the Mogollon occupy the mountains of the Mogollon Rim, manufacture brown ware ceramics and build square kivas whereas the Ancestral Puebloans occupy the Colorado Plateau to the north, manufacture gray ware and build circular kivas

(Fowler 1991; Rinaldo and Bluhm 1956). More specifically, the Mogollon are associated with the use of cradle-boarding techniques for infants that produce cranial deformation, burial of the dead in a fully extended face-up position, equal dependence on hunting and agriculture, pueblo architecture consisting of roomblocks facing inward on a plaza, the association of red and brown plain and painted ceramic wares, a scoring technique on pottery, painted clay pipes, and shell gorgets (Haury 1936:124-125; Reed 1956).

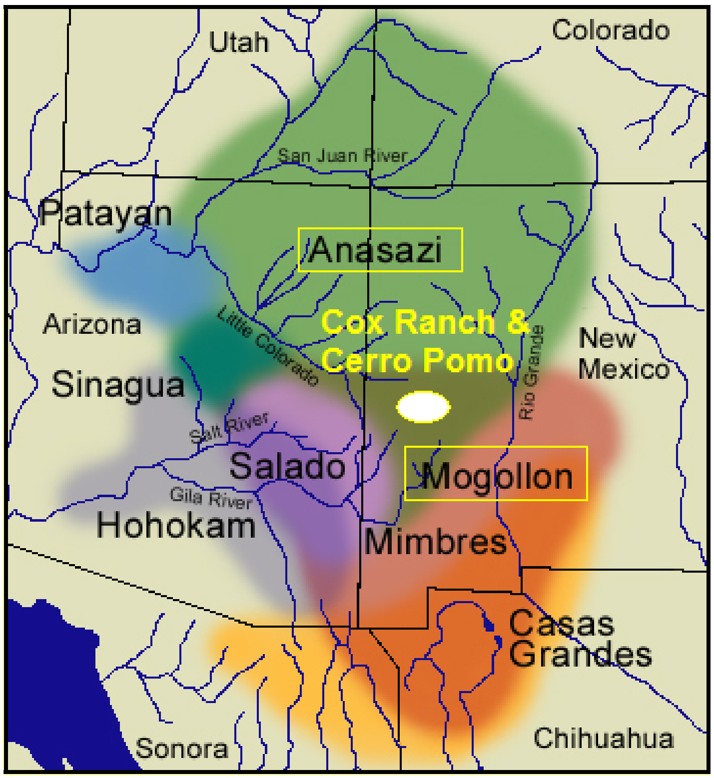


Figure 4. Distribution of Mogollon and Ancestral Pueblo Culture Areas, Showing the Location of Cox Ranch and Cerro Pomo Pueblos at the Boundary (Base Map: http://www.beloit.edu).

Haury's creation of the Mogollon as a new culture group was both praised and contested, and still is today. Joe Ben Wheat (1954) supported Haury's creation of the Mogollon with his reports of excavations at Crooked Ridge Village at Point of Pines, Arizona. Wheat (1955:229) also discusses the relatedness of Pueblo and Mogollon traditions, asserting that "there was no sharp boundary between the two, but rather, an area in which certain culture elements show blending." However, he recognizes that "throughout their histories each group maintained its own cultural integrity" (Wheat 1955:233).

The notion of strict, spatially bounded cultural traditions has outlived its usefulness in many theoretical perspectives (Mills 1999; Speth 1988; Tainter and Plog 1994; Wilcox 1988). Lekson (1996:175) argues that "we will learn more by treating the two together than we will by considering 'Anasazi' and 'Mogollon' as separate research domains." In contrast, Dean (1988:199) argues that the Mogollon concept enhanced the analytical resolution of Southwestern archaeology and has allowed us to investigate interaction between Mogollon and Pueblo groups.

I argue that these distinctions are useful when applied to material culture traits with the understanding that geographic boundaries between prehistoric culture groups were fluid—increasing evidence shows that both small and large-scale migrations took place throughout the Southwest, constantly redefining relationships between people (Cordell et al. 2007; Duff 2002). This is precisely why, with the aid of these cultural designations, we can unpack the notion of ethnic co-residence. Without the material culture distinctions, evidence of ethnicity would be nearly nonexistent. Mogollon can be defined in its original sense as a suite of technological attributes that cross-cuts geographic boundaries (Hays-Gilpin and Hartesveldt 1998:138), and as such it reflects a distinct ethnic identity. These points are well-illustrated in west-central New Mexico and east-central Arizona, where there is increasing evidence for an in-migration of Pueblo people to Mogollon sites, a blending of material culture, and, presumably, the need to communicate identity.

To further the argument that the labels of Mogollon and Pueblo are useful in discerning social organization, it must be established that distinctly Mogollon sites have been identified in the Southwest for some time, and that over time there was increased interaction between two distinct groups. The antiquity of Mogollon material culture has been well documented with early pithouse villages and brown and red-slipped pottery throughout the Arizona mountains beginning at about A.D. 200 (Haury 1941; Rinaldo 1941). Peterson (1988:113) has documented long-term Mogollon occupation in west-central New Mexico, and sees a spike in use of the area during the Reserve Phase (A.D. 1000-1150). Haury maintained that the Mogollon culture was at least as old as Pueblo Basketmaker and utilized pottery earlier in time (Reid and Whittlesey 2005:53).

After A.D. 1000, when Mogollon architectural styles shift to above-ground masonry, Haury (1958) sees evidence for a gradual merging of Pueblo and Mogollon cultures. Specifically, he credits the Mogollon with beginning the corrugated pottery tradition (post A.D. 1000) that is so prominent in later Pueblo sites. This seems very plausible given the wide variety of corrugated ceramic types in Mogollon assemblages. If a basic early Mogollon variety of material culture existed in the southern mountain Southwest, it follows that these traits were transmitted to northern groups such as the Ancestral Pueblos. This "completes the breakup of traditionalist thought, the conception of the single center with its peripheries being replaced by several cultural areas or lineages with their separate sequences and interrelated history" (Reed 1942:31). Later in his career, Haury (1988:196) became concerned that the Mogollon label was being overused and thus losing its meaning. Instead, he felt that the earlier horizons were distinctly Mogollon, but that later in time, sites in the area exhibit a mixture of Pueblo and Mogollon traits (Reid 1989:66). The large pueblos dating post-A.D. 1150 in the Mimbres, Casas Grandes, Grasshopper, and Point of Pines areas were not distinctly Mogollon in Haury's view, but instead a Mogollon–Pueblo hybrid that should be labeled "Southern Pueblo." We now know that after A.D. 1000, there was increased contact between the Mogollon and Pueblo, as well as sites where both groups lived together. However, the Mogollon retained many distinctive material culture attributes such as ceramic styles during this period.

Mogollon and Pueblo sites often exhibit intrusive material culture which clearly originates in the other tradition, namely architecture and ceramics (Dean 1988). This mixture of culture traits has been interpreted as Mogollon-Pueblo co-residence. Ethnic co-residence of Pueblo and Mogollon people has been proposed in the Southern Cibola area at sites such as Bear Village, dating as early as the A.D. 600s, though a later occupation and site remodeling cannot be ruled out (Reid 1989:72-73). This pithouse village contained both Pueblo gray ware and Mogollon brown ware ceramics, houses with distinct difference in architectural features, and mixed mortuary characteristics. Dean (1988:198) also cites large-scale mixture of Pueblo and Mogollon elements in Basketmaker III sites near Quemado, New Mexico. Nearly 600 years later, more evidence of Pueblo migrants moving into established communities is found in the mountains of the Mogollon Rim at Pueblo IV sites such as Point of Pines and Grasshopper. At Point of Pines, nearly 70 rooms, many of which were burned, were identified as home to Puebloan emigrants (Haury 1958). This begs the question of whether rising population and increased emigration created social tensions. At Grasshopper, the remains of two or possibly three ethnic groups were identified by differences in, and presence/absence of cranial deformation (Reid 1989:87). The majority of individuals represented by burials are thought to be Mogollon, while there is an enclave of only 28 Pueblo individuals. Unlike Point of Pines, there is no evidence of violence at Grasshopper.

Sites on the far boundaries of Chaco's regional system, like Cerro Pomo and Cox Ranch, maintained their Mogollon individuality in terms of cultural traditions. There was a strong Mogollon signature in material culture, and although Chacoan architectural similarity is undeniable, Chacoan imports were nearly nonexistent. "The overall pattern suggests that, despite a superficial stylistic unity across the Chaco world, different regions maintained their own substyles, which varied through time and space according to the social, political, and economic fortunes of individual Great House communities" (Kantner and Kintigh 2006:177, 180).

As I have noted, Mogollon/Pueblo interaction appears to increase through time. Pueblo II-era sites, in particular, were occupied at the height of Chaco's influence and at the beginning of proposed population growth and migration, and they may give clues to the mechanisms responsible for the resulting changes in social organization. Pueblo people likely migrated south to Mogollon-dominated sites, and these migrations are visible in ceramic traditions. However, Mogollon people were not "subsumed" into the Ancestral Puebloan lifeway—their ceramic traditions remain distinct and visible through time. More fluid concepts of culture and social use of space can be created from archaeological research into these kinds of transitional areas.

In the Southern Cibola region, Chacoan influence can be seen in dramatic increases in site frequencies after A.D. 1000, many of which center on great houses including Cerro Pomo and Cox Ranch Pueblos (Duff 2005; Lekson 1996). Cox Ranch and Cerro Pomo Pueblos are two of several large habitation sites termed Chacoan great houses on the far southern boundary of the Chaco regional system in the Southern Cibola region. The following section includes a brief discussion of the ceramic and architectural characteristics of these sites and their place within the Mogollon/Pueblo cultural framework.

Cox Ranch and Cerro Pomo Pueblos

Cox Ranch and Cerro Pomo Pueblos are located south of the Zuni Indian Reservation in west-central New Mexico (Figures 1 and 2). Research at these two sites and the surrounding communities has been conducted by Andrew Duff of Washington State University since 2002. Cox Ranch and Cerro Pomo both have Chacoan architectural attributes with large great house structures, possible subterranean ritual structures, and formal public space. Based on ceramic seriation and limited tree-ring dates, these pueblos are contemporaneous, dating to the late Pueblo II period (A.D. 1050-1130). They also fit the description of "scion communities" rather than ancestral communities, meaning that the great houses and associated community structures were constructed at the same time with no evidence for an earlier community (Breternitz et al. 1982). In most areas outside of the San Juan Basin, "ancestral communities" are the norm, with great houses appearing within areas of previous settlement. Since Cox Ranch and Cerro Pomo occur in areas with relatively little Pueblo I or early Pueblo II period settlement, this suggests that these sites were founded by migrants (Duff 2005:5). Dates and causes for abandonment of Cerro Pomo and Cox Ranch are unknown. The region did experience worsening climate and poor environmental conditions from A.D. 1130 to about 1180 (Van West and Dean 2000), and settlements appear to shift to higher elevations to the east near Mariana Mesa (Danson 1957; Duff and Lekson 2006; McGimsey 1980).

The ceramic assemblage from Cox Ranch and Cerro Pomo Pueblos and surrounding tested and survey sites totals approximately 103,237 sherds representing a one-hundred percent sample from excavated contexts and select surface grids. The basic ceramic analysis including the designation of ware, type, and vessel form was conducted by Alissa Nauman for Cox Ranch and by Melissa Elkins for Cerro Pomo with the supervision of Andrew Duff. Ceramics were analyzed using regionally defined ware-type and descriptive designations described by Carlson (1970), Colton and Hargrave (1937), Crown (1981), Fowler (1985), Hays-Gilpin and van Hartesveldt (1998), and Mills (1987, 1999). The ceramic wares in the study area include white, red, brown, and gray—all manufactured by hand with the coil method. White and red wares include both plain and black-painted varieties; brown ware is plain and corrugated with smudged bowl interiors, and gray ware is plain and corrugated. Smudging is a decorative technique accomplished in firing resulting in a lustrous black surface on bowl interiors. Wares are differentiated by paste color and slip. The decorated wares (red and white) both generally have buff-colored paste, but red wares have a distinctive thick red slip and paste that can vary from buff to orange-gray (Hays-Gilpin and van Hartesveldt 1998). Brown ware and gray ware pastes can be distinguished by their respective brown and gray paste colors, sometimes more clear on freshly broken sherds. Brown ware, however, tends to have finer paste than gray ware and exhibits polishing and smudging.

At both Cox Ranch and Cerro Pomo, the painted white ware assemblage is dominated by Puerco Black-on-white and Reserve Black-on-white types (A.D. 1030-1200). Painted red wares are dominated by Puerco Black-on-red with less Wingate Black-on-red (A.D. 1050-1200). All of these ceramic types are consistent with an occupation dating between the mid A.D. 1000s to the mid-1100s (Table 1). Early white wares such as Kiatuthlanna, Escavada, and Red Mesa black-on-white constitute less than 1 percent of the assemblage. Wingate Polychrome is also exceedingly rare. This suggests that there was limited, if any, pre-A.D. 1030 or post-1150 presence at these pueblos. At Cox Ranch and Cerro Pomo Pueblos, red ware is the least-represented ceramic type (1-2 percent of the total).

Table 1. Painted Ceramic Types at Cox Ranch and Cerro Pomo with Date Ranges (Dates from Hays-Gilpin and van Hartesveldt 1998).

Type	**Date Range**
Kiatuthlanna Black-on-white	A.D. 850-950
Red Mesa Black-on-white	A.D. 900-1050
Escavada Black-on-white	A.D. 1000-1130
Gallup Black-on-white	A.D. 1030-1125
Puerco Black-on-white	A.D. 1030-1150
Reserve Black-on-white	A.D. 1030-1200
Puerco Black-on-red	A.D. 1030-1150
Wingate Black-on-red	A.D. 1050-1200
Wingate Polychrome	A.D. 1125-1225

Assessing Contemporaneity of Cox Ranch and Cerro Pomo

To assess contemporaneity, a Correspondence Analysis (CA) of decorated sherds assigned to type from both Cox Ranch and Cerro Pomo was performed (Figure 5, Appendix A). CA is a multivariate scaling procedure that is useful for interpretation because it visually represents results as points within space (Clausen 1998). Specifically, CA can be effective for ceramic seriation because it simultaneously illustrates the patterning of ceramic types and units across a site. In this study, CA is used to order the ceramic assemblages with respect to type in a pattern that accurately reflects time (Duff 1996). In this case, Dimension 1 represents 42.77%, the majority of the variance in the sample and can be interpreted as time. Dimension 2 basically represents the continuum of early to late ceramic sherds while Dimension 1 primarily spreads time from left to right.

For the CA, only painted ceramic sherds (white and red wares) from Cox Ranch and Cerro Pomo excavations were included to illustrate their temporal relationships with site areas. Those from survey and tested community sites were not included because they are not used in further analyses. Furthermore, only specifically typed sherds were used; sherds measuring less than one-half inch were not typed and were excluded.

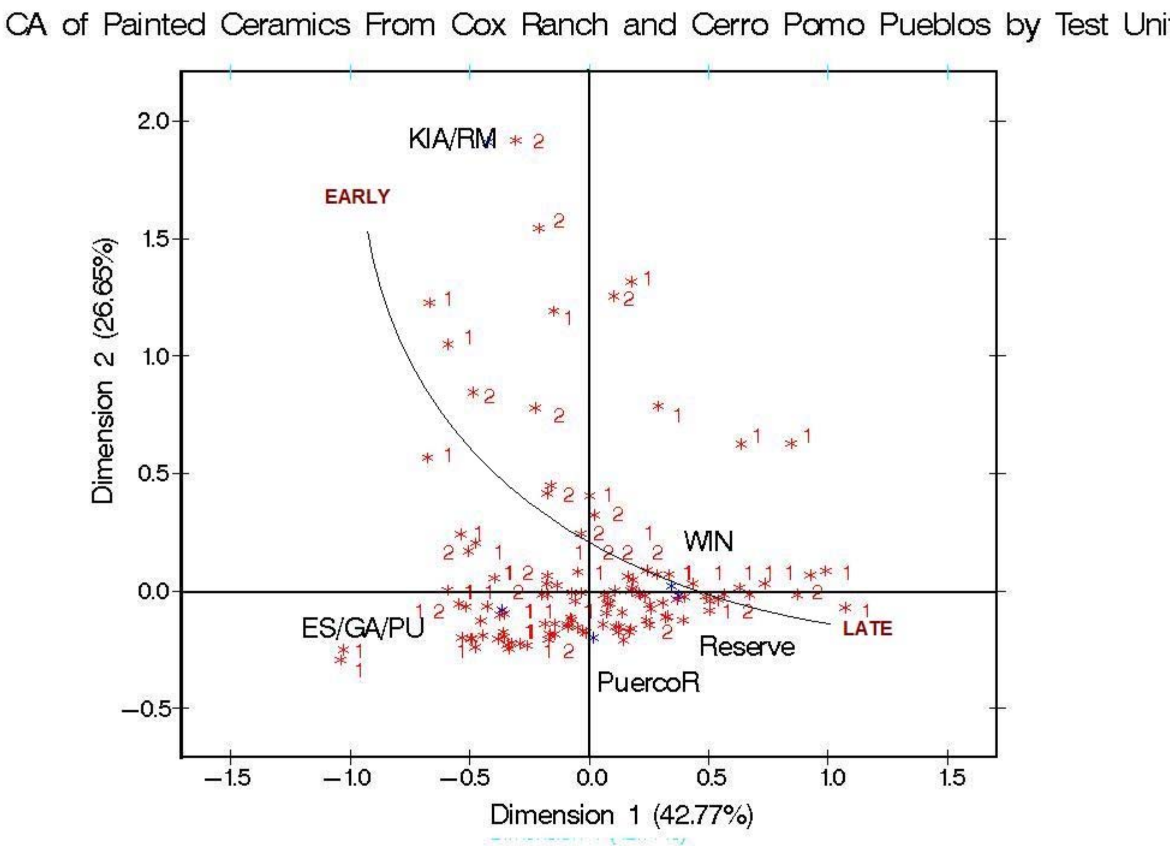


Figure 5. Correspondence Analysis Plot of Painted Ceramics from Cox Ranch and Cerro Pomo Pueblos by Site Area and Test Unit (n=52,149).

Figure 5: Key to Labels

Code	**Explanation**	**Date Range** **(Hays-Gilpin, Van Hartesveldt 1998)**
1	Cox Ranch Test Units (great house, midden, roomblocks, great kiva)	NA
2	Cerro Pomo Test Units (great house, midden, great kiva)	NA
KIA/RM	Combined totals of Kiatuthlanna and Red Mesa Black-on-white	A.D. 850-1050
ES/GA/PU	Combined totals of Escavada, Gallup, and Puerco Black-on-white	A.D. 1000-1150
Reserve	Reserve Black-on-white	A.D. 1030-1200
WIN	Combined totals of Wingate Black-on-red and Wingate Polychrome	A.D. 1050-1200
PuercoR	Puerco Black-on-red	A.D. 1030-1150

For better illustration, several ceramic types with similar dates were aggregated including Kiatuthlanna and Red Mesa black-on-white (KIA/RM), Escavada, Gallup, and Puerco black-on-white (ES/GA/PU); and Wingate black-on-red and Wingate Polychrome (WIN). On the plot, each red-colored point represents the location of a test unit within a particular area of the site (great house, midden, roomblock, etc.), while each of the five blue-colored points represents the position of the ceramic types. Each of the test units was labeled as 1 (Cox Ranch) or 2 (Cerro Pomo) for better illustration. The purpose of the CA was to determine general contemporaneity of all areas of both sites, therefore all levels within each of the test units were aggregated to facilitate clear illustration. A similar analysis could be conducted using individual levels within test units to gain a higher level of specificity.

As Figure 5 shows, there is no distinct clustering of any particular site areas represented in the plot. The majority of the test units from both sites cluster tightly near the origin of the plot, with variability in some of the units (mostly midden areas), which plot near the top. The earliest ceramic types (Kiatuthlanna and Red Mesa) are separated from the rest on the positive end of Dimension 2. Several of the midden units at Cerro Pomo also plot in this area, possibly indicating that Cerro Pomo may have a slightly earlier occupation than Cox Ranch. The later ceramic types and site units fall on the bottom right of the CA plot within Dimension 1. Ceramic types appear to be generally intermixed in all site areas of both Cox Ranch and Cerro Pomo Pueblo, indicating that they are relatively contemporaneous. Because of the relative contemporaneity of the two sites, a judgmental sampling strategy was used in this study in which ceramic sherd data from both Cox Ranch and Cerro Pomo Pueblos were combined for analyses. This analysis, based only on ceramic data, has demonstrated the similarities between Cox Ranch and Cerro Pomo including contemporaneity during the Pueblo II period and community formation possibly characterized by migration.

In the sections that follow, I provide brief descriptions of Cox Ranch and Cerro Pomo Pueblos individually to highlight some of their similarities and differences.

<u>Cox Ranch Pueblo</u>

Four years of excavation and extensive survey of the surrounding community have been completed at Cox Ranch Pueblo (LA 13681). It contains a great house, 18 room blocks, 18 discrete midden areas, and two areas with public architecture that include an unroofed kiva and a large depression likely representing a well (Figure 6). The great house is a large rectangular structure with a D-shaped wall that encloses a slightly elevated plaza (Figure 7). Walls include core-and-veneer banded masonry or Chaco “Type II” wall construction (Lekson 1986), suggesting a familiarity with Chacoan construction techniques. A berm around the great house and the pattern of the middens surrounding the great house could also be considered earthworks. The unroofed great kiva-like structure (attached to RB2, Figure 6) was not constructed using the conventions of typical Chacoan great kivas. It is not subterranean, is more oval than circular in shape, is open on two ends, and lacks obvious internal features (though this feature has only been minimally tested). This structure is, however, similar to a ritual architectural form—the unroofed great kiva—that becomes important later in the region in the early 1200s (Duff and Nauman 2003). Based on proximity and ceramic contemporaneity, smaller sites surrounding Cox Ranch appear to be part of a single residential community. Population estimates for Cox Ranch are between 200-500 people, based on the count of nearly 300 total rooms (Duff and Nauman 2003).

Surface ceramics at the site support its association with the late Pueblo II/Chacoan period (Duff 2005; Fowler et al. 1987:161-163). All of the tested portions of the site appear contemporaneous, based on ceramic seriation (Duff 2005:Figure 13), though there was undoubtedly growth over time that is obscured by dating via ceramic typology. In addition, the data suggest that Cox Ranch Pueblo was founded by a relatively large group at approximately the same time, suggesting some degree of communal planning.

The ceramic assemblage from midden, great house, roomblocks, and Cox Ranch community survey sites contains approximately 73,209 sherds, with brown and white wares each representing about 42 percent of the total (Figure 8a). Mogollon Brown Ware dominates both red and gray wares. This is an important component of the argument for ethnic co-residence as gray ware is attributed to the northern Pueblo culture. The paucity of red ware is also unusual, since the White Mountain Red Ware tradition is prevalent in nearby areas of east-central Arizona and to the north in the Zuni region (Carlson 1970). All wares occur intermixed in all contexts throughout the site. This mixture of distinct material culture suggests that the founders of Cox Ranch Pueblo came from areas both to the north and south.

Figure 8b highlights the dramatic difference between brown smudged (n=7822) and red painted bowls (n=1627). In fact, brown smudged bowls represent 25 percent of all brown ware and red painted bowls represent 42 percent of all red ware. Interestingly, even though white painted wares are numerous, the majority of them are jars—less than 10 percent of white wares are bowls. I argue that the difference between red and brown ware frequencies is the result of Mogollon people reinforcing their cultural identity with smudging, a distinct decorative type. Nearly 80 percent of all bowls are brown smudged; this is clearly the preferred style for bowls.

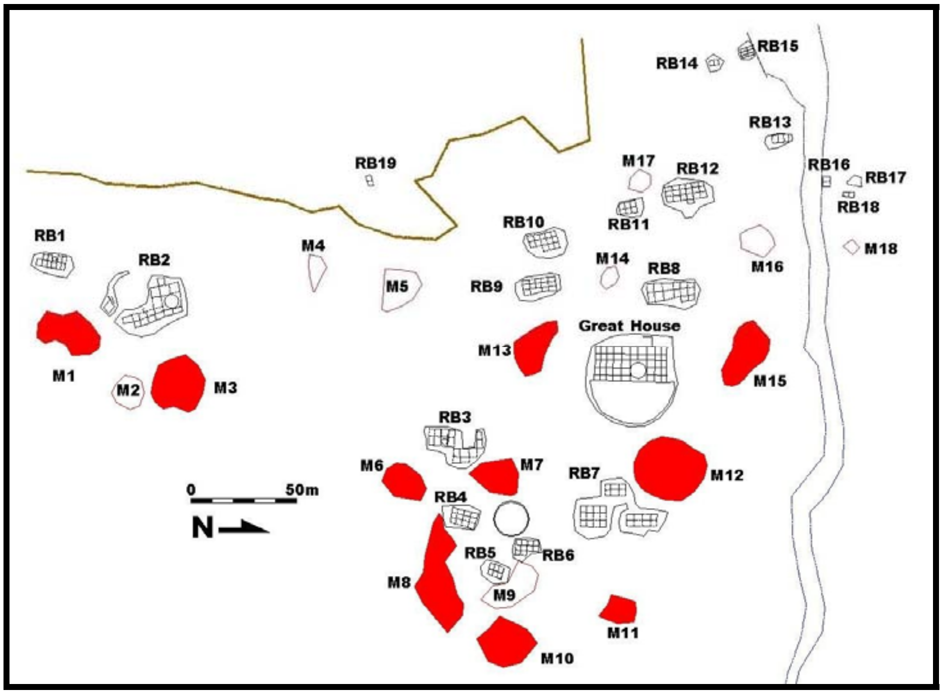


Figure 6. Site Plan of Cox Ranch Pueblo. Shaded Middens Have Been Tested.

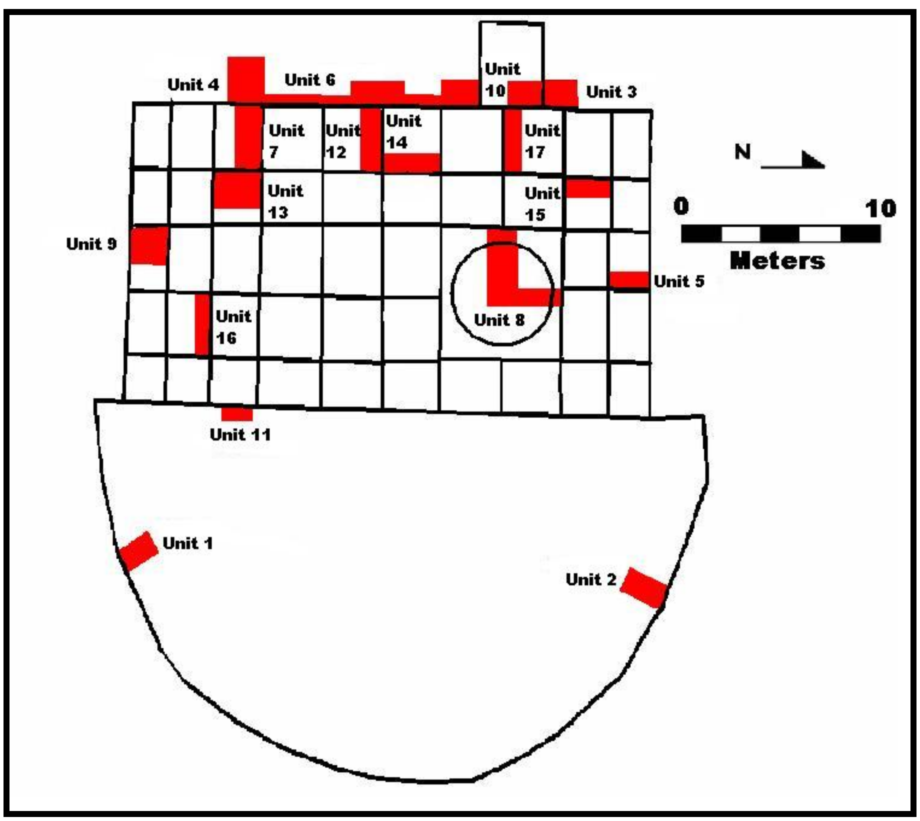


Figure 7. Detail of Cox Ranch Great House with Tested Areas Shaded.

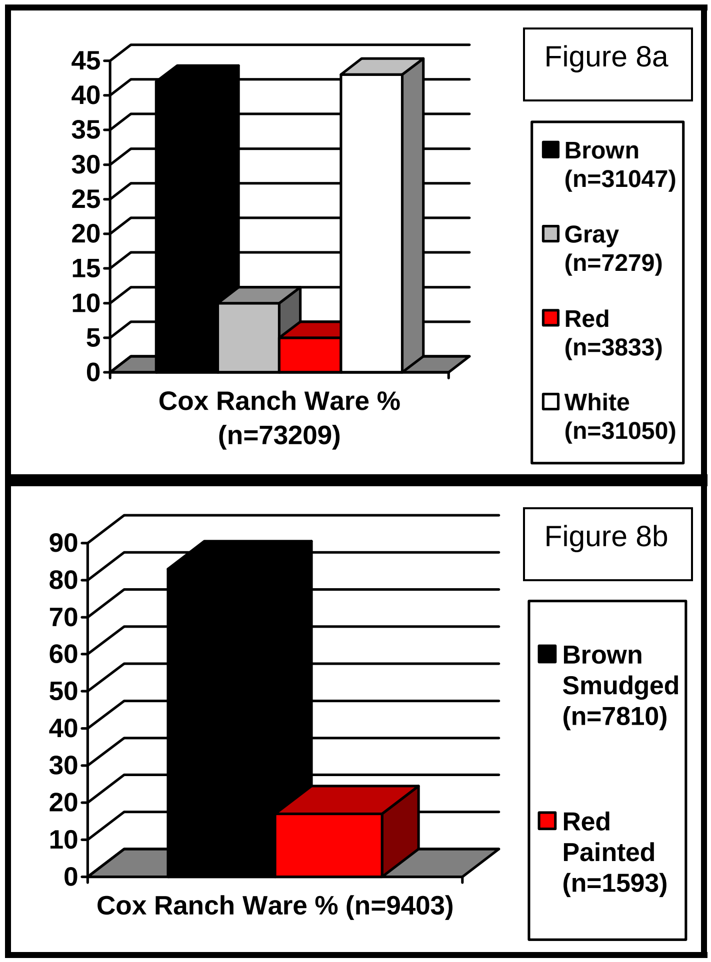


Figure 8a, b. Cox Ranch Ceramic Ware Proportions, Percentage of Total (top), and Brown Smudged and Red Painted Bowls Relative to Each Other (bottom).

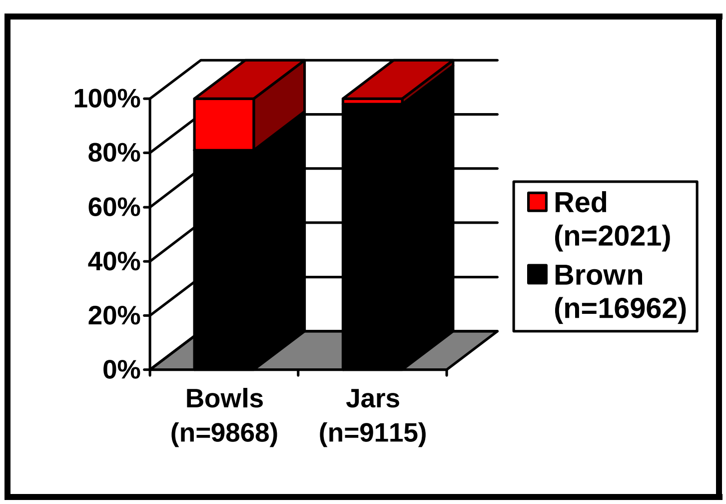


Figure 9. Cox Ranch Red and Brown Jar and Bowl Proportions (Percentage).
Brown Bowls = 8012, Red Bowls = 1856; Brown Jars = 8950, Red Jars = 165

Red painted wares are the common decorative type used as serving bowls throughout eastern Arizona and western New Mexico during this period, and may be a more Pueblo-derived ceramic type. Moreover, red painted jars are nearly nonexistent at Cox Ranch; brown ware is the preferred ware for utility vessels (Figure 9).

Cerro Pomo Pueblo

Cerro Pomo (LA 31803), the smaller of the two sites, is named for its proximity to a basalt cinder cone, a prominent feature on the landscape. It consists of a great house, large midden area, a tested pit structure or kiva immediately to the east of the great house, and two extramural depressions which may represent great kivas or other public architecture (Figure 10). Excavations at Cerro Pomo Pueblo began with limited midden testing in the summer of 2005 and continued in the summers of 2006 and 2007. Twelve 1-x-2 meter test units have now been excavated in great house room contexts, one unit in the possible kiva adjacent to the great house, and one unit in an extramural depression (Duff and Elkins 2006). Architectural attributes such as room size, shape, depth, and presence or absence of in-room floor features are quite variable throughout the Cerro Pomo great house. All rooms appear to have been cleaned out rather than trash-filled. Wall construction is variable and consists of coursed and banded masonry and adobe, some of which was plastered. Only some portions of these walls exhibit the qualities of Chacoan Type II masonry. Room floors were generally unprepared clay, with some instances of flagstone paving. Multiple floors were encountered in several areas, indicating reuse. Floor features such as hearths, a mealing bin, and a flagstone-paved adobe bench were encountered. Excavations in the great house kiva revealed a subterranean structure over 2 meters deep, numerous large burnt primary roof beams, and a clay floor with few artifacts. Tree-ring dates are hopefully forthcoming.

The results of testing in the extramural depression are enigmatic (Figure 10, upper left). A thin layer of cultural debris was encountered, and it appears that it represents a feature of unknown function excavated into natural sediments to a depth of 2 meters or more. From this feature, there is an excellent view of sunset on the summer solstice, when the sun sets behind a prominent notch on Cerro Pomo. Furthermore, this feature aligns with the unroofed kiva at Cox Ranch Pueblo, approximately 5 miles from Cerro Pomo, passing directly through the high point of the Cerro Pomo cinder cone (Duff 2006). This type of feature could have served as a community gathering place, fostering integration, or it might have been a location used by a sun watcher.

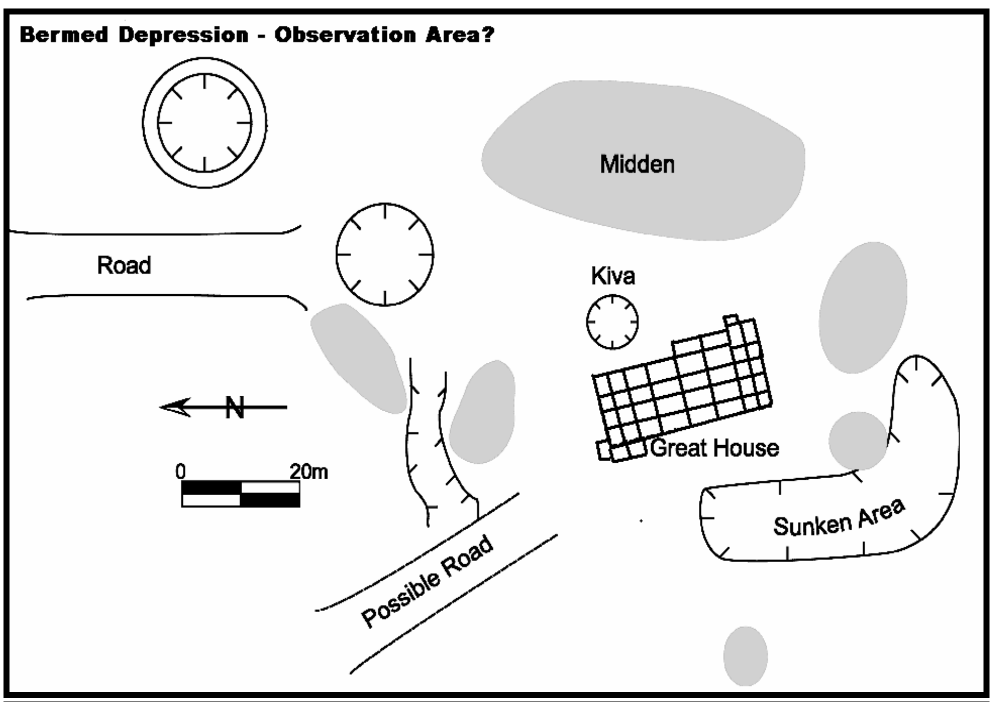


Figure 10. Site Plan of Cerro Pomo Pueblo.

The Cerro Pomo ceramic assemblage contains 30,028 sherds with ware frequencies very similar to those of Cox Ranch (Figure 11a, b). Mogollon Brown Ware accounts for half of the assemblage (n=16264), followed by white wares (n=10598). Again, red ware is the least abundant, making up only 2 percent of the collection (n=660). Brown smudged bowls clearly exceed red painted bowls (Figure 11b). Brown smudged bowls represent 17 percent of total brown ware and red painted bowls represent 37 percent of total red ware. The majority of bowls and jars are brown ware rather than red (Figure 12).

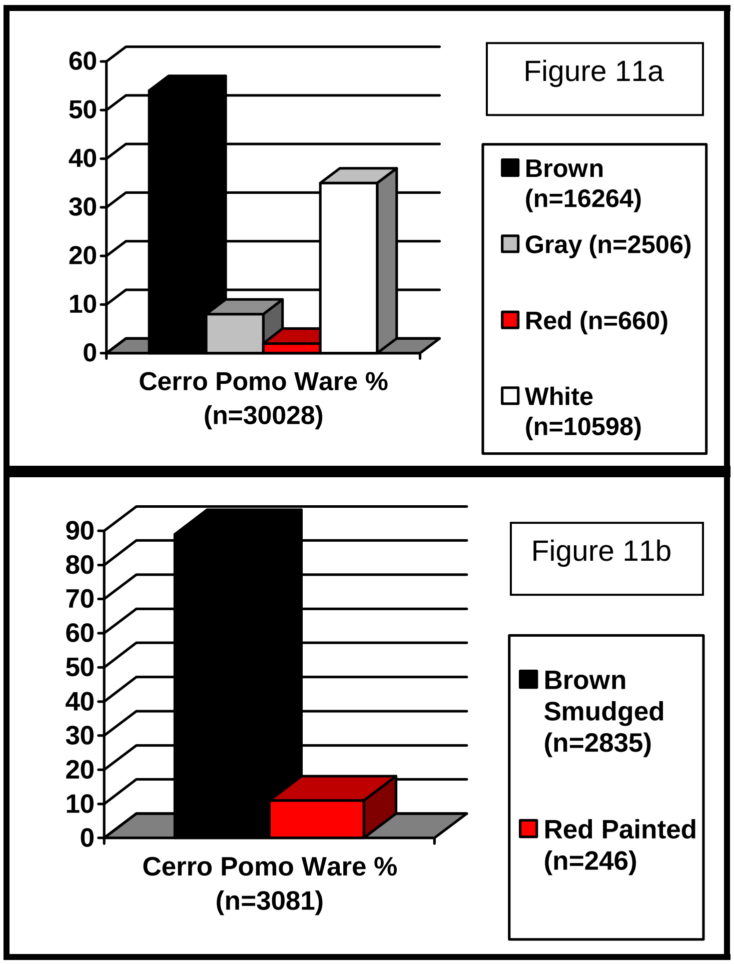


Figure 11a, b. Cerro Pomo Ceramic Ware Proportions, Percentage of Total (top), and Brown Smudged and Red Painted Bowls Relative to Each Other (bottom).

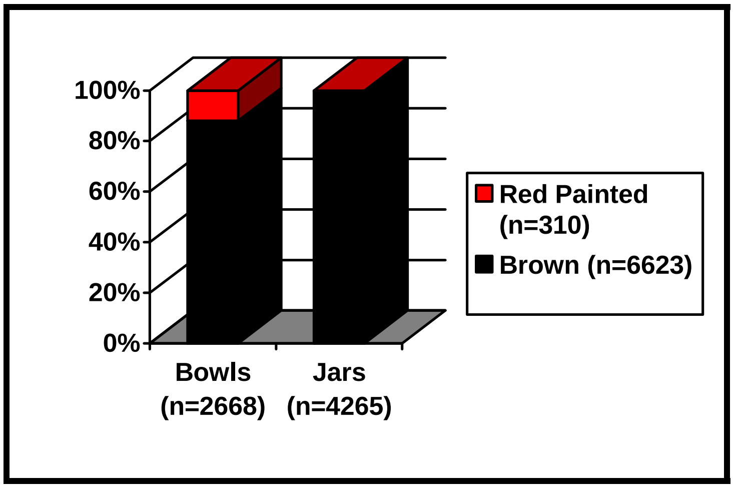


Figure 12. Cerro Pomo Red and Brown Jar and Bowl Proportions (Percentage).
Brown Bowls = 2372, Red Bowls = 296; Brown Jars = 4251, Red Jars = 14

The ceramic assemblages from Cox Ranch and Cerro Pomo demonstrate two important patterns: the overall assemblage similarity, and the overwhelming majority of Mogollon Brown Ware and paucity of Puebloan gray and red wares. The sites are contemporaneous and exhibit similar proportions of ceramic types as well as jar/bowl ratios. In fact a chi-square test indicates that there is no statistical difference between jar and bowl proportions in the Cox Ranch and Cerro Pomo assemblages (χ^2=499.3, df=3, p<.0001, see Appendix B). The fact that there are brown, gray, and red wares at these sites is particularly relevant because it demonstrates co-residence of Mogollon and Pueblo people. There is no within-site variability in the frequency of these wares—they are found intermixed in all site contexts. In other words, there were no strictly gray or brown-dominated roomblocks. The minority red and gray wares may have been imported into Cox Ranch and Cerro Pomo, but this seems unlikely for two reasons: the clays needed to make each of these wares were available locally (Nauman 2007), and though gray ware only represents about 10 percent of the total assemblage, they make up nearly 1/3 of the total jars. This seems like a large amount of the utilitarian pottery to be imported, especially since exchanged wares tend to be decorated varieties.

Cox Ranch and Cerro Pomo: Participants in the Chaco Regional System?

Cox Ranch and Cerro Pomo Pueblos are located in a transitional zone both geographically and culturally. They loosely qualify as Chacoan great houses on the far southern periphery of both the Chacoan "regional system" and the Mogollon-Pueblo culture interface, and they exhibit both Mogollon and Pueblo ceramic traditions indicating co-residence of the two groups for several generations. However, Mogollon Brown Ware clearly dominates the ceramic assemblages and likely represents a conscious attempt to signify Mogollon identity.

Chacoan architectural attributes and material correlates at Cox Ranch and Cerro Pomo are variable. Using Kantner's (2003) qualifications for membership in a regional system (regular interaction, interdependency, and unification), we can see that Cox Ranch and Cerro Pomo Pueblos do not fit the description of Chacoan "outliers" in the traditional sense. For example, Cox Ranch exhibits the classic arrangement of clustered roomblocks centered on a great house, but Cerro Pomo does not. Similarly, the classic Chacoan core-and-veneer masonry is present at both sites only in varying amounts; other wall construction methods were also used. The Cox Ranch kiva is not constructed using the conventions of typical Chacoan great kivas, being above-ground, unroofed, oval in shape, and lacking internal features. In addition, a great kiva is usually associated with the great house in classic Chacoan sites. Furthermore, local ceramic production appears to characterize Cox Ranch and Cerro Pomo Pueblos (Duff and Nauman n.d.; McDougall 2007; Nauman 2007). The sites have very few imports such as turquoise and shell that may indicate interaction with Chaco Canyon, and "Dogoszi-style" painted ceramics such as Gallup black-on-white, which some argue would indicate networks with Chaco or emulation of Chaco style, are very rare (1 to 2.5 percent of the total ceramic assemblage).

I argue that the evidence points to a loosely integrated Chacoan regional system in which autonomous communities on the "frontier" subscribed to the relevant portions of Chaco ideology but also negotiated social structure locally. The evidence does not suggest that frontier great houses were controlled by elite leaders at Chaco in the context of participation in an elaborate economic or political system. If the Chaco phenomenon was based on community ritual and integration with decentralized leadership, this fits well with the pattern we see at Cox Ranch and Cerro Pomo. Participation in this kind of Chacoan ideology could successfully integrate people with different cultural backgrounds, a situation which appears to characterize the study sites.

Previous analysis of the Cox Ranch ceramic assemblage has indicated that technologically different brown and gray wares served the same function but were manufactured from different clays (Duff, Elkins, and Wright 2006a, b; also see Chapter 6). Two distinct sets of pottery-making techniques were being utilized, likely by two distinct groups of people. More specifically, if smudging on brown ware is a stylistic technique as I argue, and smudged brown vessels are used in contexts similar to painted vessels, we would expect there to be a large number of smudged sherds relative to painted sherds in site assemblages. With this point established, I am interested in the possible interplay of brown and red wares at Cox Ranch and Cerro Pomo, and whether this pattern holds when we look at a larger distribution of sites. The following chapter provides an analysis of published ceramic frequency data for numerous contemporaneous sites in east-central Arizona and west-central New Mexico to evaluate whether or not there is spatial patterning of Mogollon and Pueblo ceramic wares.

CHAPTER 4
MOGOLLON AND PUEBLO POTS ON THE LANDSCAPE: CERAMIC WARE DISTRIBUTION, ARIZONA AND NEW MEXICO

This chapter provides an overview of the ceramic types in the study area, specifically Mogollon Brown Ware and Pueblo gray and red wares, and traces their distribution on the landscape to determine if they occur in spatially distinct areas corresponding to their respective "culture areas" (Pueblo in the north and Mogollon in the south). If so, this reinforces the geographic distinction of the two ceramic traditions which I posit are technologically different as well. An exploration of the spatial patterning of these ceramic wares helps to answer questions about intraregional migration and the resulting social organization.

Ceramics of the Southern Cibola Region

The main ceramic types in the study area include Cibola White and Gray wares, White Mountain Red Ware, and Reserve Brown Ware (Hays-Gilpin and van Hartesveldt 1998). White Mountain Red Ware (beginning circa A.D. 1000 to 1050) is a specialized ceramic technology produced in a limited area of west-central New Mexico and east-central Arizona, and it appears to be widely traded (Carlson 1970; Elyea et al. 1994:54). There is a steady increase through time in red ware ceramics, especially in the transition from Pueblo II to Pueblo III (Marshall 1991). Oxidation studies (Mills 1987:150) show White Mountain Red Ware to be the most diverse in terms of clay type, firing to buff, red, and yellow-red colors; meaning it was likely produced in several areas, as well as exchanged.

Mogollon Brown Ware dominates the ceramic assemblage at sites in the Mogollon highlands of southwest New Mexico. Mogollon Brown Ware ceramic technology includes the use of self-tempered, probably alluvial clays, neutral to partially oxidizing firing techniques, and a range of surface treatments such as smudging, polishing, and exterior corrugation. It was originally named for its association in the “core area” north of the Mogollon Rim in Arizona and New Mexico. These sherds are characteristically tempered with igneous rock from the volcanic Mogollon highlands (Hays-Gilpin and van Hartesveldt 1998).

Brown ware sherds in the Southern Cibola region are generally labeled “Reserve Series.” The typology for Reserve brown ware pottery of the Mogollon is based on ceramics from sites in the Pine Lawn Valley, the Reserve area, and the Blue River Valley area located just below the Mogollon Rim from the study area (Rinaldo and Bluhm 1956:150). The sherds are unslipped and made from self-tempered clay high in iron content and containing igneous and sandstone inclusions (Elyea et al. 1994:55; Wilson 1992). In west-central New Mexico and east-central Arizona, brown ware appears in sites dating to the Pueblo II period and later, is thought to be locally produced, and is found in association with both gray and red ware ceramics in small numbers. Nearly all brown ware bowls appear to become smudged after A.D. 1125 (McGimsey 1980). Both oxidation studies (Mills 1987) and petrographic analyses (Garrett 1987:163) show brown ware to be internally consistent. It is made from similar clays that consistently fire red and often has volcanic temper, suggesting discrete production loci.

The frequency of brown ware ceramics lessens in sites located north of the study area, traditionally thought of as Ancestral Puebloan territory, where gray and red wares are more dominant (Crown 1981; Elyea et al. 1994; Marshall 1991; Martin and Rinaldo 1950). North of Cox Ranch and Cerro Pomo pueblos, on and near the Zuni Reservation, contemporaneous unpainted assemblages are almost exclusively gray ware. Similarly, below the Mogollon Rim, utilitarian assemblages are almost exclusively brown ware whereas amounts of plain and decorated wares tend to fluctuate from site to site.

The predominance of brown ware in the Southern Cibola region during the Pueblo II period and later has been interpreted as an increasing exchange of ideas with Mogollon regions to the south or the actual migration of people (Danson 1957; Dittert and Ruppé 1951). Crown (1981:269) concludes from technological analyses of brown and gray ware from the St. Johns area of eastern Arizona (A.D. 1000-1200) that the heterogeneous brown wares represent exchange vessels from the south.

Distribution of Mogollon and Pueblo Pottery

The distribution of red and brown ware ceramics needs to be investigated further to determine the degree of cultural interaction and technology change in the Southern Cibola region. In this section, ceramic distribution is discussed at the sub-regional scale to determine if the frequency of brown ware ceramics does indeed decrease in sites located north of the Mogollon Rim, traditionally designated Pueblo territory.

Published ceramic frequency data from 24 areas in east-central and west-central New Mexico were compiled (Table 2, Figure 13, see Appendix C for ceramic counts). Each area contains varied numbers of sites; therefore, sample size is not equal throughout. However, only those sites dating to the Pueblo II to Early Pueblo III periods, and thus contemporaneous with Cox Ranch and Cerro Pomo, were selected for the study. There is some overlap in reported survey areas, and I deliberately combined data from several site groups that were in close geographic proximity, but reported separately (for example, Danson's 1957 surveys). Because these data are derived from a wide variety of reports both outdated and recent, which employ differing methods of data collection, there is potential for sampling bias. The nature of cultural resource management projects biases their location to areas of development or land exchange, and recorded sites will be skewed toward larger habitations rather than limited activity sites due to visibility. However, these data are a representation of ceramic patterning based on all available sites in the region and serve as a basis for discussing ceramic technology change on a larger scale. Compiled data includes ceramic frequencies by ware, brown smudged to red painted frequencies and proportions, and jar to bowl ratios when available (see Appendix C for raw data tables and sample sizes).

Table 2. Sites Used in the Distribution Study with Ceramic Percentages (see Appendix C for ceramic counts)

Map #	Site Group	Ceramic Percentages
1	Chaco Canyon, NM	Gray 56%, White 42%, Red 0.9%, Brown 0.8%; 98% of brown are smudged; Red Painted > Brown Smudged Bowls > Jars, Red Bowls > Brown Bowls, Red Jars > Brown Jars, Brown Bowls > Brown Jars
2	Sander’s Great House, AZ	Gray 57%, White 27.6%, Brown 11%, Red 4.2%; 17% of brown are smudged; Brown Smudged > Red Painted Red bowls > red jars, Brown bowls > red bowls, Brown jars > brown bowls
3	Zuni, Y Unit Draw, NM	Gray 52%, White 33%, Red 13.9%, Brown 0.8%, 66.6% of brown is smudged; Red Painted > Brown Smudged NO jar / bowl data
4	Fort Wingate, NM	Gray 72%, White 21.8%, Red 5.3%, Brown 0.4%; no smudged; Red Painted > Brown Smudged Red bowls > Red Jars, Jars > Bowls
5	El Malpais Nat. Mon., NM	Gray 54%, White 35.7%, Brown 8.5%, Red 1.4%, 4.4% of brown are smudged; Red Painted > Brown Smudged Red Painted > Brown SM, Red Bowls > Red Jars, Brown Bowls > Red Bowls, Brown Jars > Brown Bowls
6	Silver Creek, Carter Ranch AZ	Brown 64%, White 29.7%, Red 4.4%, Gray 1.7%; 7.9% of brown is smudged; Brown Smudged > Red Painted NO jar / bowl data
7	Danson – Nutrioso, Springerville - Little Colorado	White 47%, Brown 44%, Red 7.5%, Gray 1.2%, 16% of brown smudged; Brown Smudged > Red Painted NO jar / bowl data
8	TEP St. Johns, AZ	White 40%, Gray 35.7%, Brown 14.9%, Red 9%, 62.5% of brown are smudged; Brown Smudged > Red Painted Brown bowls > Brown jars, Red bowls > Red jars, Red bowls > Brown bowls
9	Mineral Creek, AZ	Brown 55%, White 40%, Gray 2.2%, Red 2%, 11.8% of brown smudged; Brown Smudged > Red Painted; NO jar / bowl data
10	Danson - North Plains & Mariana Mesa	Brown 55%, White 40%, Gray 2.2%, Red 2.2%, 11.8% of brown smudged; Red Painted > Brown Smudged; NO bowl / jar data
11	Armijo Canyon, NM	White 51.7%, Gray 23.5%, Brown 23%, Red 1.6%; 10% of brown bowls smudged Brown Smudged > Red Painted, Brown jars > brown bowls, Red bowls = red jars, Brown bowls: > red bowls
12	Cebolla Canyon, NM	White 46.5%, Gray 47%, Brown 1.6%, Red 4.7%, 33% of brown are smudged Red Painted > Brown Smudged, Brown jars > brown bowls, Red bowls > red jars, Red bowls > brown bowls
13	Danson - Rio Salado-Alamocita	57% Brown, 36% Gray, 33% White, 6% Red; 21% of brown are smudged; Brown Smudged > Red Painted NO jar / bowl data

Table 2 (Cont.)

14	NZ Survey, NM	White 50%, Gray 33.6%, Brown 12%, Red 4.2%; 44% of brown are smudged; Red Painted > Brown Smudged NO jar / bowl data
15	Fence Lake Mine Excavations, AZ, NM; Carrizo Wash Valley AZ; San Augustine, NM	Gray 57.8%, White 26.5%, Brown 14%, Red 1%, 10% of brown are smudged Brown Smudged > Red Painted, Brown bowls > red bowls, Red Bowls > Red Jars, Brown Jars > Brown Bowls
16	Mariana Mesa, NM	Brown 46%, White 36.7%, Red 14%, Gray 3%: 8% of brown is smudged; Red Painted > Brown Smudged Red bowls > Red jars, Red bowls > Brown bowls, Brown jars > Brown bowls, Brown jars > Red jars
17	Danson - Tularosa River, Apache Creek, Hardcastle Creek - Perry Lawson	Brown 85%, White 9.5%, Red 5.2%, 0 Gray; 17% of brown is smudged, Brown Smudged > Red Painted NO jar / bowl data
18	Danson - Gallo Mt. - Jewett Ranger Station, Johnson Basin - Seven Troughs	Brown 76%, White 17%, Red 5.8%, Gray 1.2%; 19% of brown are smudged, Brown Smudged > Red Painted NO jar / bowl data
19	Danson - Largo Canyon - Agua Fria	56.8% Brown, 29.9% White, 9.8% Gray, 3% Red Of Brown, 14.6% smudged, Brown Smudged > Red Painted NO jar / bowl data
20	Danson - Blue River & Upper San Francisco River	96.5% Brown, 2.2% White, 0.4% Gray, 0.8% Red; 6.2% of brown smudged; Brown Smudged > Red Painted NO jar / bowl data
21	Pine Lawn Valley, NM	Brown 92%, White 5.6%, Red 1%, Gray 0.7%; 16.7% of brown is smudged, Brown Smudged > Red Painted NO jar / bowl data
22	Reserve Caves, NM	Brown 89%, Red 7%, White 3%, Gray 0.1% Brown Smudged > Red Painted; NO jar / bowl data
23	Tularosa, NM	Brown 91%, White 6.4%, Red 2.4%, 1 Gray sherd; 24% of brown is smudged; Brown Smudged > Red Painted NO jar / bowl data
24	Danson - Mimbres, Lower Gila, Lower Blue - San Francisco Rivers	Brown 85.7, White 14%, Red 0, Gray 0 No smudged NO jar / bowl data

When the percentages of all brown and red ware ceramics from each site group are compared, a loose pattern emerges (Figures 13 and 14). As expected, red ware frequencies generally decline from north to south. The greatest proportions of red ware are in the northwest samples (map #1-4), and the smallest proportions of red ware occur in the south (map #17-24). The most red ware overall is in the Zuni area (map #3) on the north edge of the New Mexico cluster, and the least overall is in the Blue and Upper San Francisco River area (map #23). Data from the Chaco project (site group #1) was included to show that nearly equal amounts of smudged brown ware and red painted ware were imported long distances into Chaco Canyon. This reinforces brown smudged ware's status as prized decorative pottery.

The middle portion of the sampled areas (map #5-16) are more variable – they exhibit varying amounts of red and brown ware rather than a distinct north to south trend. These areas are yellow on the map (Figure 13), whereas the brown and red-dominated areas are shaded in their respective colors. Interestingly, the middle area roughly correlates with the Southern Cibola region, a frontier zone between the Mogollon and Pueblo culture areas, which I hypothesize exhibits co-residence of these two groups. Cebolla Canyon (map #12), located on the east-central portion of the study area, is an anomaly, exhibiting an unusual spike of red ware. Brown ware frequencies are relatively high throughout the sample. Because of the slight fluctuation in red ware variability, the patterning may be better explained on a site-specific level, but overall the pattern holds.

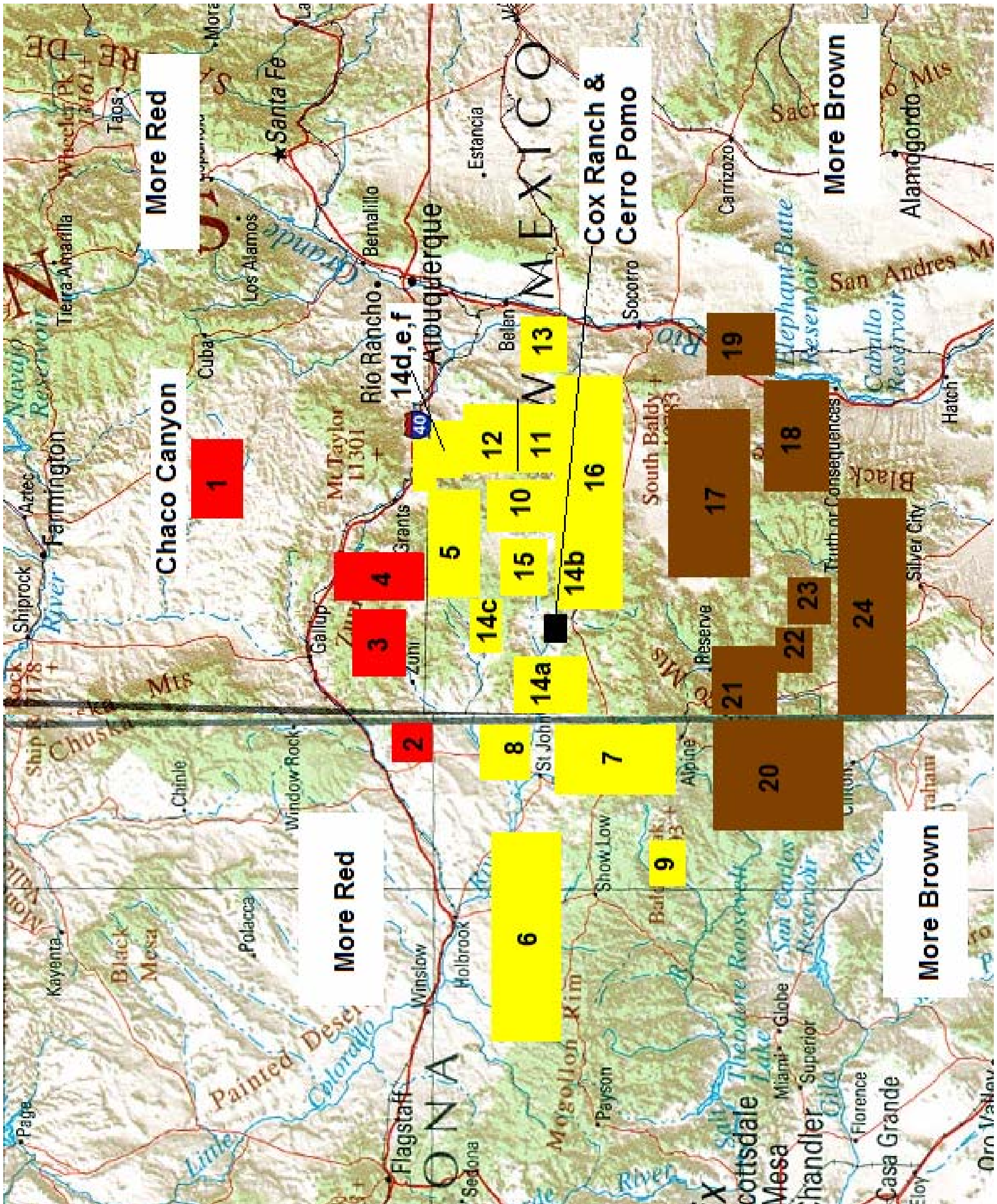


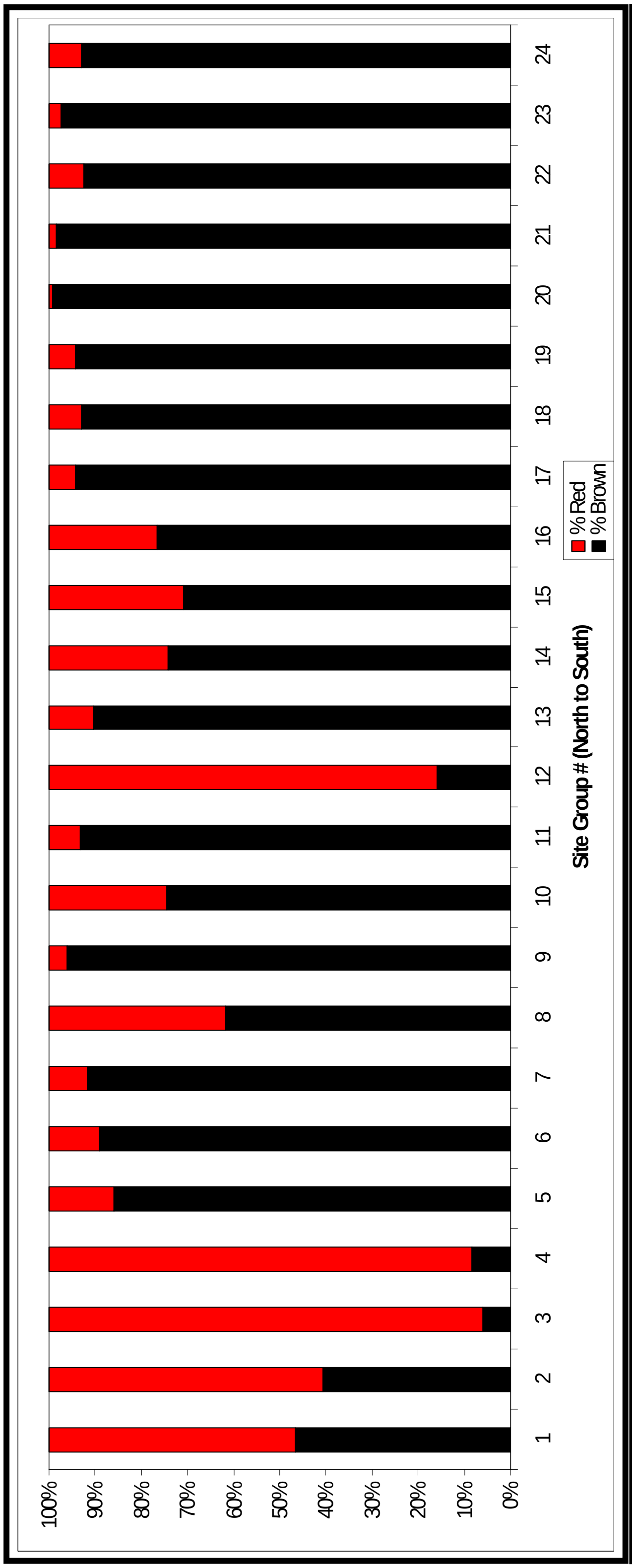
Figure 13. Site Areas with Published Ceramic Data Used for Regional Analyses. (Area sizes are relative, they are not to scale).

1: Chaco Project
2: Sanders Great House
3: Zuni, Y Unit Draw
4: Fort Wingate
5: El Malpais
6: Silver Ck, Carter Ranch
7: Nutrioso, Springerville, Little Colorado
8: TEP St. Johns
9: North Plains
10: North Plains
11: Armijo Canyon
12: Cebolla Canyon
13: Rio Salado-Alamocito
14a-f: NZ Survey
15: Fence Lake Mine
16: Mariana Mesa
17: Tularosa R, Perry Lawson
18: Gallo Mt., 7 Troughs
19: Largo Canyon, Agua Fria
20: Blue-Upper San Francisco R
21: Pine Lawn Valley
22: Reserve Caves
23: Tularosa
24: Mimbres-Lower San Francisco R

When we look only at brown smudged and red painted sherds, brown smudged ware is most prevalent at the sites furthest south (Figure 15). In this view, the brown ware sample becomes more representative because it excludes plain brown vessels, likely utilitarian jars. The strongest patterning is again seen on the far southern portion of the region where brown smudged ware is present in large numbers to the near exclusion of red painted ware. Again, map numbers 5 through 16 (the Southern Cibola region) exhibit variability.

Interestingly, the same pattern is exhibited between brown and gray ware proportions; brown ware increases dramatically further south in the study area and the central portion of the study area exhibits variability (Figure 16). This point reinforces the north-south distinction of the Puebloan gray ceramic tradition and that of the Mogollon brown. It is also interesting to note that the Silver Creek area (map #6) which is one of the northern site groups but has large numbers of brown ware, falls within the Mogollon cultural boundary by some definitions (Martin 1979).

Lastly, when we examine the bowl-to-jar ratios between red and brown wares throughout the region, we see, not surprisingly, that brown ware was preferred over red for jars and the majority of red wares are bowls (Figure 17). Red ware jars were likely used for water storage, whereas brown ware jars were cooking vessels. Bowl and jar counts were provided for only a small portion of the study sites (ten of the 24 areas used in the distribution).



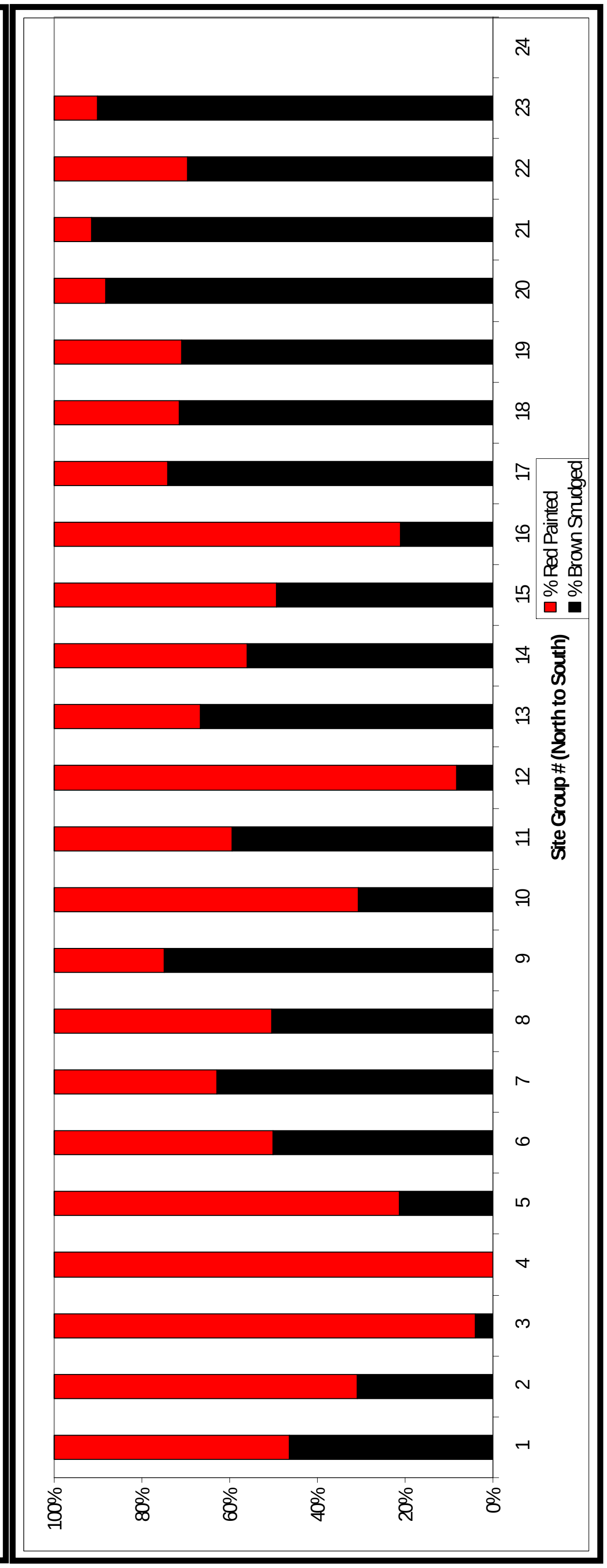


Figure 14 (left). Distribution by Site Group from North to South of All Brown and Red Ware. Figure 15 (right). Distribution by Site Group from North to South of Smudged Brown and Red Painted Bowls.

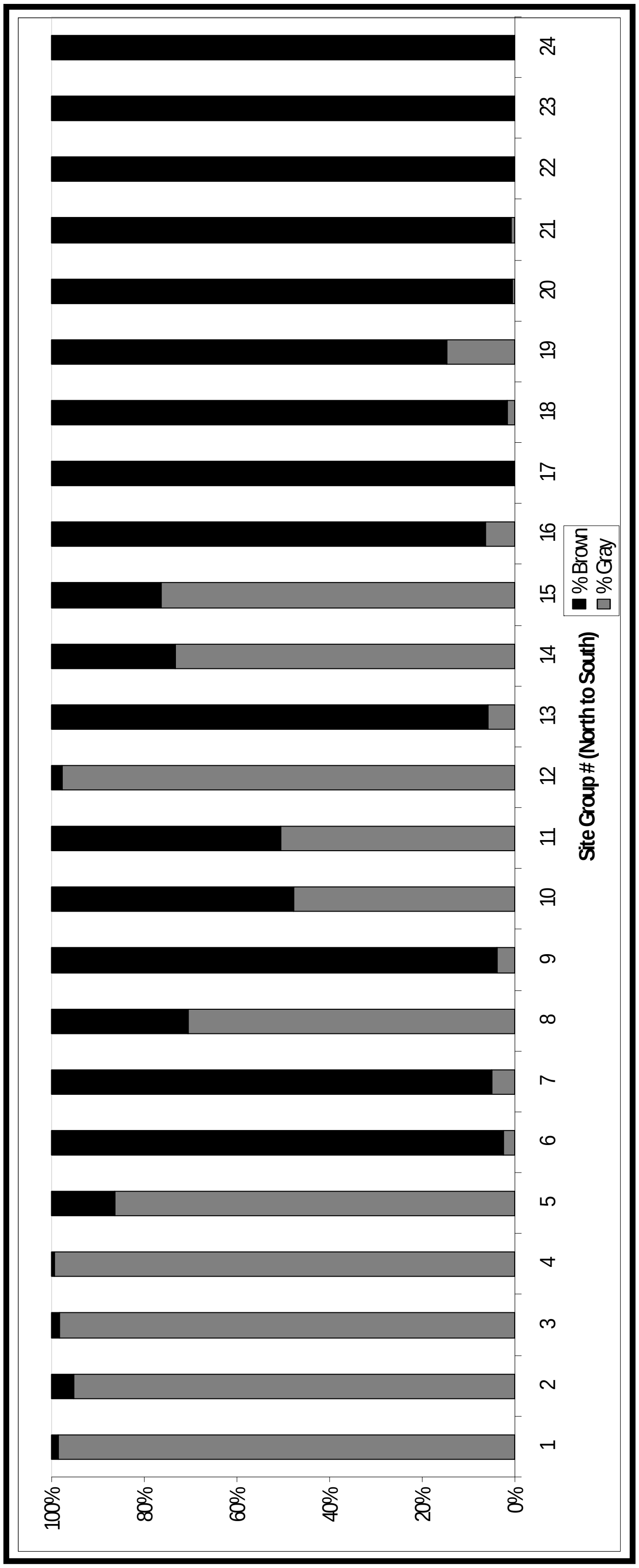


Figure 16. Distribution by Site Group from North to South of All Brown and Gray Ware.

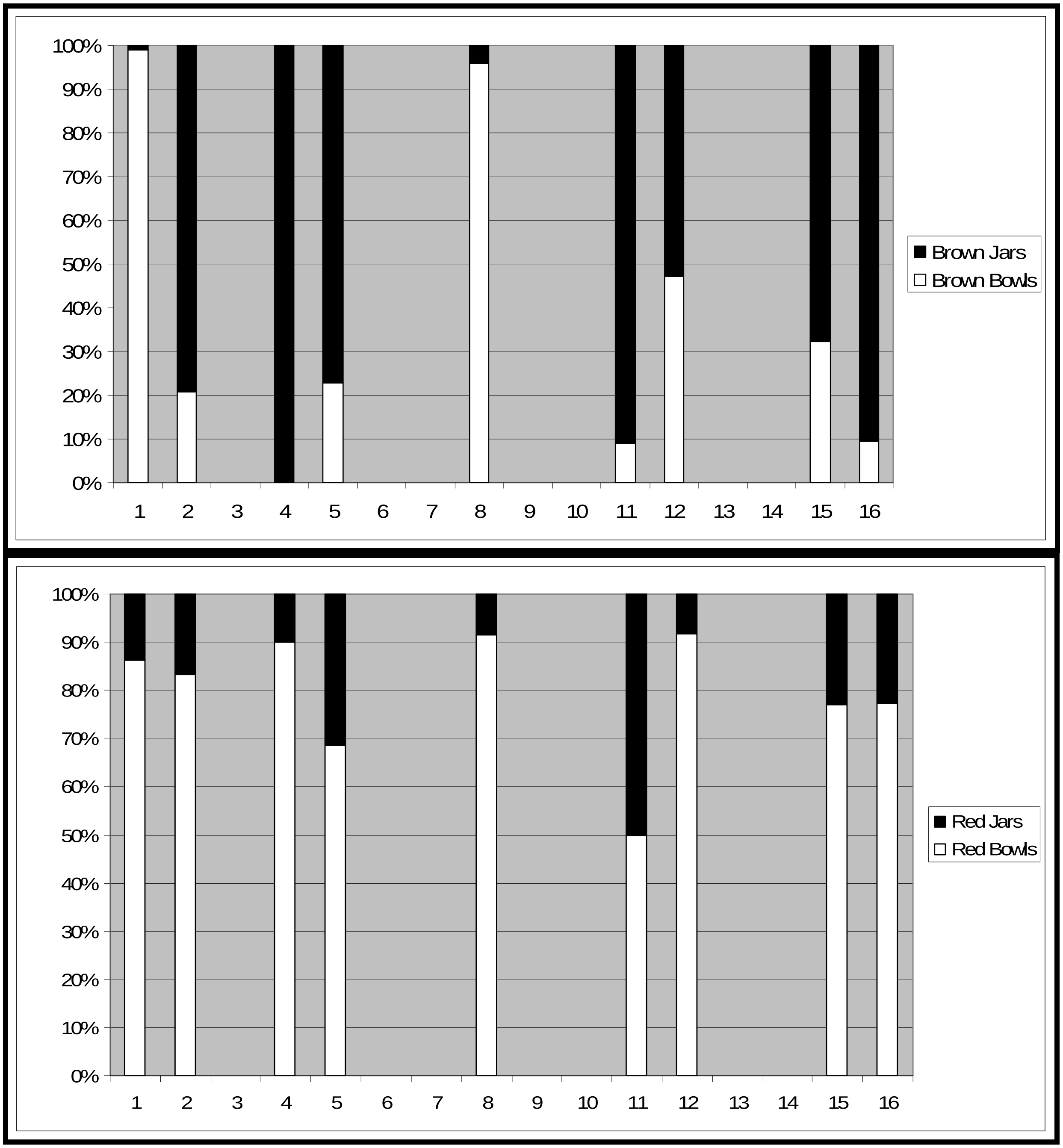


Figure 17. Jar / Bowl Ratios (percentage) for Brown Ware (top) and Red Ware (bottom).

There is no distinct north-south patterning in jar-to-bowl ratios (Figure 17). Sites in the TEP-St. Johns, Arizona area have an unusually high number of both brown and red bowls which may indicate a specific site function. Site group #1 (data from the Chaco project) also stands out for a high percentage of bowls, indicating the importance of imported bowls at Chaco Canyon proper.

In summary, there is roughly a northeast to southwest trend (see Figure 14) of increased use of brown smudged ware. In general, it appears that the further south from traditional Pueblo territory we go, the more potters utilized brown smudged bowls. The brown smudged pottery tradition has historical roots in the Mogollon area to the south. The ceramic patterning also highlights the presence of distinct Mogollon and Pueblo ceramic traditions in the Southern Cibola region consisting of brown and gray and red wares, respectively (Figure 14, map #5-16) which has both Mogollon brown and Pueblo gray and red wares.

The distinct geographic patterning of ceramic wares likely results from small-scale migrations and co-residence of Mogollon and Pueblo people, and mirrors that of Cox Ranch and Cerro Pomo. It remains to be seen whether both groups founded communities like Cox Ranch and Cerro Pomo together, or northern Pueblo people moved into established Mogollon sites. However, the material culture shows that the Mogollon tradition was dominant, an intuitive result if Pueblo people were migrating south into Mogollon transitional areas. In sum, these data suggest that potters were choosing to manufacture brown smudged bowls rather than red painted ones, likely their functional equivalent. People with distinct Mogollon social histories may have wanted to reinforce a familiar historical tradition, especially in an environment characterized by migration and integration of new people into a community. The ties to this historical tradition appear to dominate other social and material ties to Chaco Canyon in these frontier communities.

CHAPTER 5
MAKING POTTERY FABRICS SPEAK: METHODS

This chapter consists of descriptions of each of the methods used for analyses to help answer research questions related to differences in vessel size, function, and raw material for gray, brown, and red ceramic wares. These include vessel diameter estimates from sherds and whole vessels in museum collections, oxidation studies, measurements of apparent porosity, temper characterization, protein residue, and gas chromatography/mass spectrometry. All statistical analyses were conducted using SPSS 12.0 and SAS 9.1 for Microsoft Windows.

Individual potters build their ceramic vessels slightly differently depending on the way they were taught. These differences are elements of technological style that can be detected in the finished product. Specifically, these analysis methods can help us to discern whether or not Mogollon and Pueblo potters with distinctive traditions lived together at Cox Ranch and Cerro Pomo and intentionally maintained these differences in pottery manufacture.

Rim Arc

In order to assess whether brown and red bowls were functionally similar as suggested by the distribution data (Chapter 4), we need to determine if they were manufactured in similar size ranges. Rim arc is a method for estimating a vessel's diameter from the radius of sizable rim sherds, using a rim-fitting chart with the plane of the rim's lip held horizontally (Rice 1987; Shepard 1980). The rim-fitting chart is used to find the closest fit between the degree of curvature of the rim and a series of concentric circles (Plog 1985, see Appendix D for example). This constitutes a radius measurement in centimeters from which diameter can then be calculated (by doubling the radius). Rim arc analysis has been critiqued because of the common problem raised by rim asymmetry; rims may be uneven vertically or horizontally, making it difficult to estimate the precise orientation and diameter of the sherd (Shepard 1980:223). Furthermore, diameter estimates can be subjective and differ significantly between analysts (DeBoer 1980; Plog 1985).

Plog (1985) suggested an alternative method for estimating rim diameter known as the chord-and-distance method. Although this method may be more precise than using the rim-fitting chart, its drawback is that it is more time-consuming and much larger sherds are needed. Whalen (1998:221) finds that although we cannot determine the volumes of individual vessels, the rim-fitting method is effective for reconstructing the rough composition of an assemblage in terms of broad vessel size categories. In the Cox Ranch and Cerro Pomo great house ceramic assemblages, there is a relatively small number of rims (approximately 2.6 percent of the total) and they tend to be on the smaller side (5 to 10 cm). Therefore, the rim-fitting chart was the best option for analysis.

With these limitations to rim arc data in mind, the analysis can still be useful, providing insight into relative vessel size, especially when all data are collected by one analyst. A single analyst conducting all rim arc reduces potential variability in assigning size categories. In the current study, the rim arc data are made more robust by comparing them to whole vessel size data. To further maximize accuracy in the data, I only included sherds 3 cm in width or larger, and excluded sherds which could be assigned to more than one radius category.

For this study, I collected rim arc data for 100% of the red painted, brown smudged, and white painted bowl rim sherds (n = 561 sherds, Appendix E) collected from the great houses at Cox Ranch and Cerro Pomo only. Only bowl forms were included in this portion of the study, as I am restricting my research questions to decorative ceramic forms. Ceramic data from midden and roomblock contexts at these sites, as well as those from tested and surveyed sites in the surrounding community were not collected. This sampling strategy was chosen for three reasons: the great houses have the most ceramics; restricting the sample to similar contexts in both sites facilitates comparison between the two; and including additional community sites would introduce variation in time and space, and potentially function, to the sample. I concentrated on Mogollon Brown Smudged and White Mountain Red Ware painted bowl rims to determine their size differences, but also collected data on Cibola White Ware painted bowl rims for comparison. I predict that Mogollon Brown Smudged and White Mountain Red Ware painted bowls will exhibit similarities in vessel size, and this serves as one proxy for both wares having a similar function.

Museum Collections

When making predictions about vessel size relating to function, measurements of whole vessels are of course ideal, as the accuracy of sherd rim arc data is somewhat in doubt. To gather data on whole Mogollon Smudged Brown and White Mountain Red Ware bowl sizes, I visited four museums with sizeable Southwestern ceramic collections and gathered data on 307 vessels, of which 228 were used in statistical analyses (Table 3, Appendix F). Again, I collected data on a small number of whole white ware vessels for comparison (n=16). I restricted my data for statistical analyses to only those ceramic types which date to the Pueblo II and early Pueblo III time periods. Most of these vessels are from private collections and therefore lack site provenience (Table 4). Every vessel was photographed with a scale in 35 mm as well as digital format. Whole vessel sizes of smudged brown ware and red ware were compared to determine if similar sizes equate to similar function. In other words, were both brown and red ware bowls used similarly as serving bowls?

Several measurements were taken on each of the whole vessels studied, including rim and base diameters, and vessel height. A cloth tape measure was used for these measurements, which were recorded in centimeters. In addition, digital calipers were used to measure rim thickness and corrugation width (when applicable) in millimeters. A vessel has three essential components: orifice, body and base (Rice 1987: 212). One important characteristic is the

Table 3. List of Museums Visited for Whole Vessel Size Data

Museum	Location	Number of Vessels
Western New Mexico University Museum	Silver City, New Mexico	50 Brown, 2 Red
Maxwell Museum of Anthropology	University of New Mexico, Albuquerque	16 Brown, 31 Red, 6 White
Museum of Indian Arts and Culture, Laboratory of Anthropology	Santa Fe, New Mexico	32 Brown, 22 Red
Field Museum of Natural History	Chicago, Illinois	24 Brown, 35 Red, 10 White

Table 4. Whole Vessel Known Site Proveniences by Ware

Ware	Site Provenience
Brown	WS Ranch, Catron Cty NM; Little Colorado Ruin, AZ; Alma Ruin, Catron Cty NM; Parker Ruin, AZ; Mitchell Ruin, Grant Cty NM; Zuni Salt Lake, Catron Cty NM; Spur Ranch, Catron Cty NM; Apache Creek, Catron Cty, NM
Red	Higgins Flat Pueblo, AZ; Casamero Site, Pruitt NM; Chaco; Broken K Pueblo, AZ; Mitchell Ruin, Grant Cty NM; Foote Canyon Pueblo, AZ
White	Lowry Ruin, CO

relation of the orifice to the vessel's maximum diameter. Use classifications of vessel shapes are most often accomplished with ratios of height to maximum diameter and size of orifice (Longacre 1981; Rice 1987:215; Shepard 1980:238). Differences found in these attributes between wares can serve as a proxy for vessel function.

In ceramic use studies, volume and geometry are used to infer vessel function using the designations for solids: sphere, ellipsoid, and ovaloid; and surfaces: cylinder, cone, and hyperboloid (Rice 1987:219). The capacity of most vessels can be calculated by a combination of these geometric forms. With the simple form of serving bowls, I was able to rely on measurements of rim diameter and height. Vessel volume could not be directly measured with the collections (i.e., with rice or a similar filler), as it was not allowed by the museum staff for these fragile vessels. Therefore, vessel volume was calculated after Rice (1987:221) using two different formulas; one for the volume of a spherical segment and one for the volume of a hemisphere. These calculations were compared for accuracy, and a Student's *t*-test was run on the ceramic data set with each volume value to determine whether the choice of calculation had a direct effect on the overall results. Either calculation results in similar volume values (see Chapter 8). The formulas are as follows:

1) Volume of a Spherical Segment $\mathbf{V_{SS} = \pi r^2(r-h/3)}$

Where π equals 3.14159, *r* equals measured radius, and *h* equals measured vessel height

2) Volume of a Hemisphere $\mathbf{V_H = 2/3 \pi r^3}$

Where π equals 3.14159, and *r* equals the measured radius

Because bowl forms are generally similar, and the bowls in the collections tended to be consistently sized and shaped, a calculation of vessel volume is considered accurate for my research.

Oxidation Studies

Oxidation studies, or ceramic refiring experiments, are important in the current study because they allow us to compare the clay properties of brown and red ware sherds by measuring their refired color. In this way, we can determine if different ceramic types were made from similar or different clays. Furthermore, these data can be compared to natural clay samples from the area to determine if manufacture was local or nonlocal (Mills 1987; Shepard 1980). If both red ware and brown smudged bowls could be made locally at Cox Ranch and Cerro Pomo, then the preference for brown-firing clay is reinforced. These inferences are limited however, by our knowledge of potential clay sources in the area.

The principle of oxidation studies of ceramics is to hold the firing conditions constant so that the color of the paste is a more direct measure of clay composition. Once a sherd is refired, the original firing conditions do not contribute to the sherd's paste color. Munsell colors of refired sherds can then be used to examine raw material differences between samples. Sherds from different vessels are refired by exceeding the original firing temperature in order to directly compare the clays (Fowler 1991:136), providing insights into the clay properties independent of intended function and firing atmosphere. For the current study, sherds were refired in an electric kiln to a temperature of 900 degrees Celsius in an oxidized atmosphere for one hour.

The color of fired pottery is determined primarily by the firing conditions (atmosphere, duration, and temperature) and the composition of the clay (Shepard 1980:103). Similar clays fired under similar conditions generally will produce similar colors. In other words, sherds with similar refired colors were probably made from the same clay; whereas high variability in refired color may indicate numerous clay material sources or technological traditions. The atmosphere of firing has a great effect on color development through the abundance or scarcity of oxygen (Rice 1987:335). When refired in an oxidizing or oxygen-rich atmosphere, at a temperature high enough to drive off all organic matter, clays containing less than 1.5 percent iron oxide will refire to a white or cream color, clays with 1.5-3 percent iron oxide content refire to buff (yellow to light orange), and clays with more than 3 percent iron oxide refire to a red or dark orange color (Windes 1977). An oxidizing atmosphere with high temperatures will destroy any organic material left in the clay, exposing the iron content which contributes to the paste color (Rice 1987:344). Sherds with higher iron content will refire to darker shades of red. Guided by these predictions of firing color, Windes (1977) developed Munsell color ranges for refired ceramics grouped along a buff-to-red scale, later modified by Mills (1987). Mills' color ranges were used in the current oxidation studies (Table 5) of 164 brown ware and 75 gray ware sherds from Cox Ranch Pueblo (Appendix G). Firing subjects pottery to heat for a sufficient amount of time to completely destroy the clay-mineral crystals, the temperature for which can vary from 500 to 900 degrees Celsius (Rye 1981:96; Shepard 1980:83).

Table 5. Munsell Color Groups for Oxidation Studies (Mills 1987:148;Windes 1977)

Color Group	Munsell Color Designation
1 Red	2.5 YR 4/4-4/8, 5/4-5/8, 6/4-6/8
2 Yellow-Red	5YR 5/4-5/8, 6/6-6/8, 7/6-7/8; 7.5YR 5/4-5/8, 6/6-6/8, 7/6-7/8, 8/6
3 Buff	5YR 7/1-7/4, 8/1-8/4; 7.5YR 7/1-7/4, 7/6-7/8, 8/1-8/4, 8/6-8/8; 10 YR 7/1-7/4, 7/6-7/8, 8/1-8/4, 8/6-8/8

Oxidation studies can help to identify the range of variability in the kinds of clays potters used, whether particular clays were used for different forms or decorative types, and whether different firing practices were used for different ceramic wares (Rice 1987:344). Specifically, I consider whether or not Mogollon and Pueblo ceramic wares were made from different clays and what this may indicate about potters' choices for manufacture.

Apparent Porosity

In order to infer the original use of ceramic vessels, it is necessary to study their physical properties. Clay properties affect the ability of a ceramic vessel to successfully hold liquid and dry loads, withstand changes in heating and cooling for cooking, and survive impacts. Physical, mechanical, and thermal ceramic properties also provide information on vessel manufacture and the nature of raw materials (Rice 1987:347).

Specifically, clay microstructure can be studied with measurements of apparent porosity (Rice 1987:351). Apparent porosity is the ratio of the volume of pore space to the total volume of the ceramic sherd. It expresses the relative volume of the open pores in clay. It is related to a sherd's capacity to absorb water, and is expressed in weight rather than volume. Data on apparent porosity aid in answering questions about the intended properties of the ceramics when they were used. A measure of apparent porosity on unaltered sherds (as recovered) provides data relevant to original vessel function, whereas differences in the apparent porosity of refired sherds evidence differences in raw material. Again, clay composition can be directly measured in refired sherds because the firing condition has been made constant, eliminating this variable's contribution to differences in sherd color. Clay differences will be exposed because firing changes their physical properties. However, it must also be noted that temper added to raw clay also alters the clay properties, and potters make intentional choices about what type of, and how much temper to add to a ceramic vessel based on its intended function.

What do high and low porosity values mean and how do we use them in ceramic research? High porosity increases a pottery vessel's absorption of carbon and its resistance to thermal shock (Shepard 1980:125-126). The porosity of commercial ceramics can vary from less than one percent to as much as 90 percent, but earthenwares (most directly comparable to archaeological pottery) vary from 20-25% (Rice 1987:352). In sum, high porosity is needed for pots which are exposed to high degrees of thermal stress. However, porosity also increases permeability and seepage, making high porosity undesirable for boiling or storage vessels (Curet 1997:500). Porosity also affects heat conductivity because pots with high numbers of closed pores (low porosity) will have lower conductivity than pots with open pores (high porosity). Air trapped in the closed pores serves as an insulator, whereas large open pores permit heat to pass through the clay body effectively. Successful cooking vessels will often have large open pores. In contrast, effective serving vessels should have a high number of closed pores since they tend to be good insulators (Curet 1997:500-501). We would expect that serving bowls would generally exhibit moderate to low measures of porosity because unlike cooking vessels, they are not exposed repeatedly to direct high temperatures.

A test of apparent porosity is conducted by collecting dry sherd weight, then saturating the sherd in water by boiling it for an hour, after which it remains immersed for at least 24 hours. Next, the sherd is towel-dried to remove excess water, and a water-saturated weight is collected. Finally, the sherd is weighed while suspended by a string in a cup of water to collect a measurement of water displacement. The weights are used in the following formula to calculate apparent porosity (Shepard 1980:127):

$$\frac{\text{Weight of Saturated Sample} - \text{Weight of Dry Sample}}{\text{Volume of the Sample}} \times 100$$

Weight is integral to the apparent porosity calculation to derive volume. The volume of the sample (total volume of sherd) is calculated by subtracting the suspended weight from the saturated weight. In addition to apparent porosity, I examine the volume of open pores for the red and brown ware sherds alone (weight of saturated sample – weight of dry sample) because a high degree of closed pores will be desirable in serving vessels for good insulation (Curet 1997:501).

For gray, red, and brown ceramic wares, the apparent porosity of un-refired sherds was used to determine the original use of the vessels. I predict that plain brown and gray jars were used for cooking or storage and will therefore exhibit higher unrefired apparent porosity values, and that red painted and brown smudged bowls were used as serving dishes and will exhibit lower unrefired apparent porosity values. The measures of apparent porosity on refired sherds allow us to compare raw materials across wares, and I predict that white, gray, brown, and red wares, which exhibit distinctly-colored pastes, were manufactured from different types of clay that were intentionally chosen by the potters. These data can reveal whether the residents of Cox Ranch and Cerro Pomo Pueblos were using fundamentally different clays to manufacture different ceramic wares and whether these clays were available locally.

In the Cox Ranch Pueblo brown-gray case study (see Chapter 5), apparent porosity data were collected for a total of 468 sherds: 326 brown ware jars and 142 gray ware jars (Appendix H). For the study of brown and red ware bowls (see Chapter 7), apparent porosity data was collected for 345 sherds from Cox Ranch only (Appendix H). These analyses are on-going by Dr. Andrew Duff and Darin McDougall, and a comparative sample from Cerro Pomo Pueblo will be available soon.

Temper Analyses

A preliminary temper analysis was conducted only on the brown and gray sherd sample (n=239) from Cox Ranch Pueblo (see Chapter 5, Appendix I). Temper may be defined as the coarse components of a clay paste added by potters to modify the clay's properties. Temper analyses served to identify differences in the raw materials used for the temper of different ceramic wares, similar to the measure of refired apparent porosity. Analysis of temper from the Cox Ranch Pueblo ceramic assemblage was conducted with the aid of a binocular microscope set at 40x magnification, and inspections were conducted along fresh fractures. Each sherd was subjected to the same series of observations concerning the type, amount, shape and size of temper within the sherd's paste.

In order to identify the range of variation in temper, the following variables were recorded and later collapsed into broader categories to facilitate meaningful statistical comparison. With the aid of proportion estimating charts, the total proportion of temper to the ceramic paste and the proportions of each type of temper were classified into three ranges including low (< 5%), average (5 – 20%) and high (> 20%) (MacBeth Division of Kollmorgen Instruments Corporation 2000). The shapes of the non-basaltic sands were classified into three broad categories modified from Power's (1953:118) designations and include angular, sub-rounded and rounded. Differences in the shape of the sands may indicate different temper sources or the preference of a particular shape. The sizes of the sands and crushed rocks for each sherd were generalized into three particle size classes designated by Wentworth (1922): medium (.25 - .5 mm), fine (.125 - .25 mm) and very fine (.0625 - .125 mm).

A more thorough examination of temper from Cox Ranch and Cerro Pomo ceramics is being conducted by Caitlin Wichlacz, Washington State University, as part of her in-progress thesis research.

Protein Residue Analysis / Gas Chromatography-Mass Spectrometry

Although size similarities among different ceramic vessels can be indirectly used to predict similar function, direct measures of function are more elusive. Protein residue analysis, however, is one measure that can be performed on ceramic sherds to identify prehistoric exploitation of plants and animals for food. Protein residue analysis is an immunological or forensic method that isolates trace residues on artifacts left behind from food processing activities. It is appropriate for archaeological and forensic materials alike because both deal with residues that have undergone deliberate or natural changes (Yohe 2007:1). Although protein residue analysis techniques are incredibly sensitive, protein preservation is extremely variable especially over long periods of time, and results can be "hit-or-miss." There is every reason to believe that proteins and carbohydrates are released during food processing and absorbed by the porous ceramic fabric of vessels. These compounds, however, may be readily lost from pot sherds into the soil after burial. Furthermore, unique aspects of clay chemistry may impact protein preservation, specifically the fact that the pH of water at the clay mineral surface (4-5.5 pH) may be sufficiently acidic to destroy these compounds (Evershed and Tuross 1996; McCabe 1992).

Four ceramic sherd samples from Cox Ranch and Cerro Pomo Pueblos were sent to the Laboratory of Archaeological Sciences at California State University, Bakersfield (CSUB) for protein residue analyses (Table 6). The samples included two red painted wares and two brown smudged wares, to facilitate comparison of the possible function of each. These sherds were selected based on their larger size and provenience within great house rooms.

Table 6. Samples Analyzed for Protein Residue

Sample #	**Ware / Type**	**Site**	**Provenience**
1932	Red Painted Bowl Rim	Cox Ranch Pueblo	Great House Unit 12, Level 3, Locus 1
2564	Whole Brown Smudged Bowl	Cox Ranch Pueblo	Great House Unit 17, Level 5, Locus 1 10North, 10East, 134 cm below datum, Point Location #1
2913	Wingate Black-on-Red Bowl Rim	Cerro Pomo Pueblo	Great House Unit 1, Level 1, Locus 1
3105	Indented Corrugated Smudged Bowl	Cerro Pomo Pueblo	Great House Unit 3, Level 6, Locus 5

These samples had been washed in water only which should not compromise proteins. Protein residue analyses have limited potential for highly carbonized materials, as high temperatures severely denature proteins. In addition, thermally altered cooking vessels exposed to long-term temperatures of 75 degrees Celsius and long-term temperatures of 100 degrees celsius likely have compromised fatty acid and protein residues (Norman Henrikson, CSUB, personal communication 2007). However, none of the samples used in this analysis were from clearly burnt contexts, and they are all serving bowls rather than cooking vessels.

The CSUB laboratory specifically used a method termed *Cross-Over Electrophoresis* (CIEP), which was used by forensic laboratories to identify crime scene residues before the advent of DNA fingerprinting. CSUB tested the sherds for 26 known animal and plant antiserae. Appendix J provides an in-depth description of these methods (Yohe 2007:2).

Many researchers have had greater success in characterizing lipids, rather than proteins, on ceramic artifacts with a method termed Gas Chromatography/Mass Spectrometry or GC/MS (Bonfield and Heron 1995; Eerkens 2002, 2005; Evershed et al. 1992; Evershed and Tuross 1996; Heron et al. 1991; Patrick et al. 1985). Proteins and carbohydrates are generally considered to be intrinsically less resistant to degradation than are lipids (Evershed and Tuross 1996:430). Despite some difficulties in preservation and extraction, there is evidence that the lipid components of the organic residues on potsherds including fatty acids, waxes, sterols, resins, tars, pitches, and amino acids can be related to the range of plant and animal matter that had come into contact with the archaeological vessels during food preparation, cooking, or storage (Eerkins 2005; Evershed et al. 1994). The porous nature of unglazed and unpainted pots makes them particularly good candidates for the absorption and retention of organic materials (Eerkens 2005:84).

GC/MS, a method used widely in many scientific fields but still in its infancy in archaeology, has much promise for discerning vessel function. The basic assumption of residue studies is that different plants and animals produce different types and quantities of organic compounds and pottery absorbs these compounds during use. Organic materials from foods, especially fats and oils, essentially clog the pores of a pot where they are sealed and preserved until liberated for analysis (Eerkens 2005:87). Furthermore, Heron et al. (1991) assert that residues are not subsequently contaminated by surrounding soil deposition, so we can be fairly certain that a pot's residues are related specifically to its use. Similar to all types of protein residue analysis, in-situ oxidation and hydrolosis can contribute the most to the decomposition of lipids on ceramic sherds (Christie 1989).

GC/MS is actually two techniques that are combined to form a single method of analyzing mixtures of chemicals, and it has been borrowed by archaeologists from the fields of medicine, chemistry, environmental science, and law enforcement. In its simplest terms, gas chromatography is used to separate mixtures of chemicals into individual components which can then be identified separately, and the quantities of each can be counted. Mass spectrometry is used to create a graphic representation that is essentially a fingerprint for the molecule, and can be used to identify the compound. The results of the Mass Spectrometry constitute ratios of lipids that can be matched to reference spectra in the National Institute of Standards and Technology (NIST) 98 Mass Spectral Library (Eerkens 2005:88). The library reports a list of likely identifications along with the statistical probability of the match. For an in-depth description of GC/MS see George Mason University's Shared Research Instrumentation Facility (SRIF) at www.gmu.edu/departments/SRIF/tutorial/gcd/gc-ms2.htm, and Appendix K.

GC/MS reveals general food classes (plant and animal) that may have been used in pottery rather than specific types. Malainey et al. (1999) have shown that it is possible to differentiate various food classes with fatty acids. In rare instances, an analyst can conduct finer food identifications when a specific biomarker is found that is distinctive to a certain species or genera. An interesting example of this is Eerken's (2002) GC/MS study of a single brown ware sherd from the surface of a Shoshone rock shelter site in the Great Basin that revealed the presence of terpenes, demonstrating that pinon resins were prepared in the pot in prehistoric times. The fact that the sample was from the surface context of a site encourages us to suspect that lipids can be extremely well-preserved on ceramic sherds. It should be noted that this sherd was only one of a sample of 75 sherds that exhibited a specific biomarker, however GC/MS of the remainder of the sherds revealed more generally that they were used to cook plants, especially seeds, with fewer used for meats (Eerkens 2000, 2005). In general, it is recommended that large samples of sherds be subjected to GC/MS in order to have confidence in assigning them to food categories and in isolating trends in the data for pottery function, because highly accurate one-to-one assignments of sherds to food products is unrealistic (Eerkens 2005:99).

I submitted six samples—three brown smudged and three red painted sherds—to Dr. Mary Malainey of Brandon University, Manitoba for GC/MS analysis (Table 7, Appendix K). This analysis was funded with a grant from the New Mexico Archaeological Council. Results from these studies should help to identify general classes of foods used in the pots, and to elucidate any differences between the two wares.

Table 7. Samples Analyzed for Fatty Acids with Gas Chromatography/Mass Spectrometry

Sample #	Ware / Type	Form	Site	Provenience
1064	Red, Wingate B/R	Bowl	Cox Ranch	Great House Unit 7, Level 3, Locus 1
2573	Brown, Indented Corrugated Smudged	Bowl	Cox Ranch	Great House Unit 16, Level 7, Locus 1
2597a	Brown, Plain Smudged	Bowl	Cox Ranch	Great House Unit 17, Level 6, Locus 1
2597b	Red, Puerco B/R	Bowl	Cox Ranch	Great House Unit 17, Level 6, Locus 1
2615	Red, Puerco B/R	Bowl	Cox Ranch	Great House Unit 16, Level 10, Locus 1
3486	Brown, Plain Corrugated Smudged	Bowl	Cerro Pomo	Great House Unit 12, Level 6, Locus 2

Summary

All of the above-mentioned analysis methods (Table 8) are used to determine whether or not two distinct technological traditions linked to the Mogollon and Pueblo people are being maintained at Cox Ranch and Cerro Pomo, and more specifically whether or not brown smudged bowls (present in high numbers in the collections) had similar functions to red painted bowls.

Table 8. Summary of All Analyses Conducted

Analysis Type	**Sample Size / Site**
Whole vessel measurements (museum collections)	228/ Various -- Arizona, New Mexico
Rim arc	561/ Cox Ranch and Cerro Pomo Great Houses
Oxidation studies	239 / Cox Ranch
Apparent Porosity	468 / Cox Ranch
Temper characterization	239 / Cox Ranch
Protein residue	2 each Cox Ranch and Cerro Pomo
Gas Chromatography / Mass Spectrometry	5 / Cox Ranch, 1 / Cerro Pomo

In the chapter that follows, I provide a case study which illustrates how technological style can be studied in utilitarian gray and brown ware jars from Cox Ranch Pueblo. The similarities and differences in Mogollon and Pueblo pottery traditions are assessed using measures of apparent porosity, oxidation studies, and temper characterization.

CHAPTER 6
THE BROWN AND THE GRAY: TECHNOLOGICAL STYLE AT COX RANCH PUEBLO, A CASE STUDY

In this chapter, I discuss the results of my analyses of technological style of brown and gray ware sherds from Cox Ranch Pueblo, which confirms the co-residence of Mogollon and Pueblo people, two distinct ethnic groups. These analyses were conducted as part of a graduate-level ceramics course (ANTH 514) in the Spring of 2006 which led to the presentation of two papers (Elkins, Duff, and Wright 2006 a, b, 2007) and a publication in progress. This study created the basis for my current research questions related to Mogollon and Pueblo identity presented in this thesis. If two different ceramic technologies are represented in utility wares at Cox Ranch community sites, then it follows that a similar pattern would exist with decorated wares. Thus, a comparison of brown and red ware sherd technology followed.

Midden assemblages at Cox Ranch Pueblo contain abundant utilitarian pottery—both Mogollon Brown Ware and Cibola Gray Ware—attributed to two distinct historical traditions in quantities that suggest it unlikely that patterning results from exchange (see the end of this chapter for further discussion). Unpainted brown and gray ware jars, traditionally cooking or utility wares, were exclusively analyzed using vessel attributes, sherd refiring experiments, and temper analyses. This research addressed three main questions. First, were brown and gray ware vessels intended for the same use? Second, are there differences in how the vessels were manufactured, suggesting similar or different technological styles? Third, what resources were used to manufacture these vessels and are they locally available?

The methods used for this study include measurements of apparent porosity, comparison of clay source material by means of oxidation studies, and microscopic analysis of sherd temper.

A total of 468 jar sherds from Cox Ranch Pueblo were used in this analysis; 326 brown wares and 142 gray wares (Appendices G, H, I).

In the current study, apparent porosity was calculated twice for all 468 sherds; once on the sherds as recovered, and once on the sherds after refiring. A measure of apparent porosity on the unaltered sherds provides data relevant to original vessel function. Data from this portion of the experiment is used to determine whether or not gray and brown ceramics were intended for the same use. The measures of apparent porosity on unrefired sherds are slightly different, as shown in box plots by ware (Figure 18). Brown ware has a mean unrefired apparent porosity of 19.6, whereas gray ware has a mean of 22.6. An Independent Samples *t*-test with equal variances assumed confirms that the mean difference between brown and gray unrefired apparent porosity is statistically significant ($t = -8.1$; $d.f. = 466$; $p = .000$).

This result is unexpected, especially since a smaller data set (n=239) of brown and gray wares exhibited statistically similar mean unrefired apparent porosity values (Elkins, Duff, and Wright 2006). We would assume that both brown and gray vessels were designed to achieve a similar functional goal as cooking pots. Therefore, we cannot be certain that the differences in brown and gray ware jars aren't merely caused by differential use. It is possible that the less porous brown ware was used for food storage whereas the more porous gray wares were used for cooking. As we have seen, high porosity is desirable for pots which are exposed to high thermal stress usually associated with cooking (Curet 1997; Shepard 1980). However, it is also possible that the apparent porosity values for both brown and gray jars (20 to 23 percent) is within the expected range for cooking pots. Rice (1987:352) states that the apparent porosity of archaeological pottery can vary by as much as five percent (20-25%). In addition, the common values of apparent porosity of prehistoric pottery generally fall between 20 and 30 percent and the “optimal” pore size for cooking vessels may range from 7 to 9 mm (Rye 1976:114, 1980:122). In sum, although the differences between gray and brown unrefired apparent porosity are statistically significant with a large sample, the natural range of variation in porosity supports the proposition that they served a similar function.

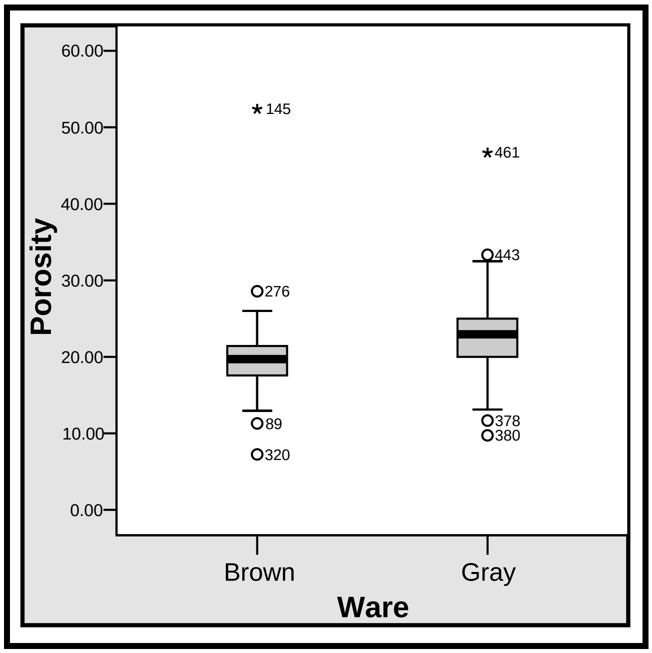


Figure 18. Apparent Porosity (%) of Unrefired Brown and Gray Ware Sherds.

Next, chips of a smaller sample of each ware (n=238) were refired for one hour in a kiln to a temperature of 900^0 Celsius to observe refired paste color. The refired color of brown ware sherds was predominantly red and yellow-red, while the gray ware were overwhelmingly shades of buff with a smaller proportion of yellow-red (Figure 19). Thus, the clays selected for manufacture of gray and brown wares were different. It is important to note that gray ware sherds can be made using clays that fire red under oxidizing conditions, provided they are not exposed to oxygen while being fired. However, brown ware sherds require iron-rich clays and an oxidizing firing atmosphere.

As noted above, a second set of porosity measurements was taken on the refired sherds (n=468) as an indication of raw material differences. Measures of sherd apparent porosity after refiring naturally exhibit differences because the properties of the clay have been changed (Rice 1987). These measures are no longer an indication of original use, but are another indication of raw material and temper.

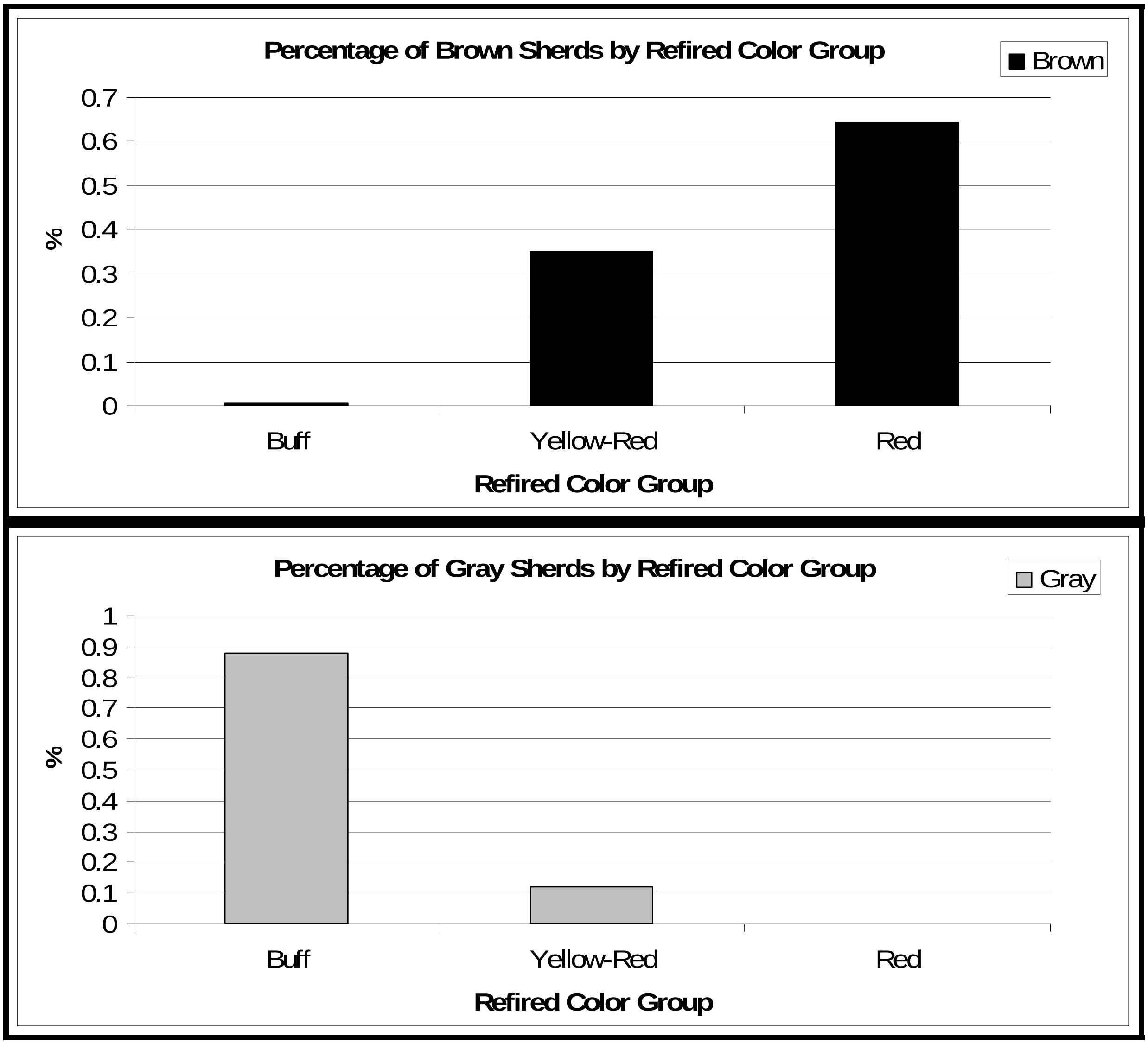


Figure 19. Refired Sherd Color by Ware—Brown (Top), Gray (Bottom).

The measures of apparent porosity on refired sherds exhibit some variability, as shown in box plots (Figure 20); the range of values for gray wares is larger than that of brown wares. The mean refired apparent porosity for brown ware is 21.5, compared to 23.5 for gray ware. This differentiation could indicate that brown and gray ware were manufactured from inherently different clays. In fact, an Independent Samples *t*-test reveals that the mean difference between the refired apparent porosity of brown and gray wares is statistically significant (*t = -5.3; d.f. = 466; p = .000*).

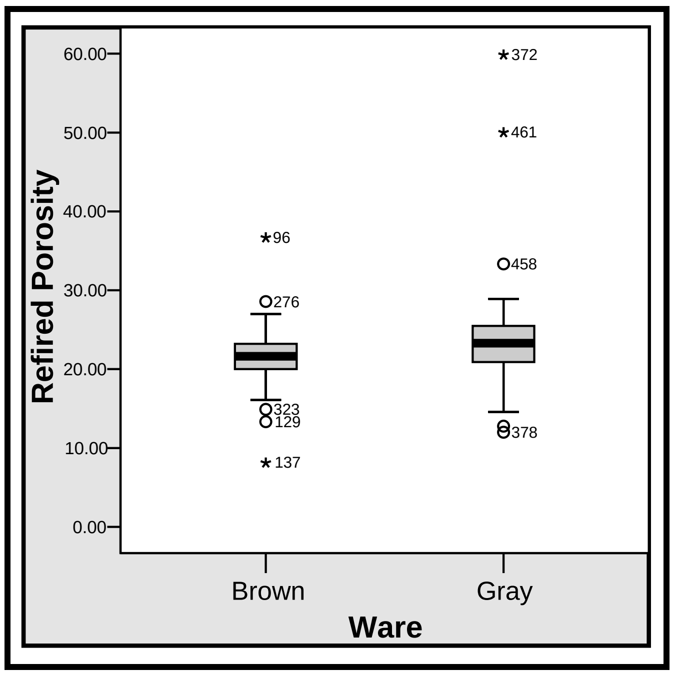


Figure 20. Apparent Porosity (%) of Refired Brown and Gray Ware Sherds.

When the values of apparent porosity for the subset of sherds with refired color data (n=238) are sorted by the refired color group, it becomes apparent that the distributions of sherds (brown and gray combined) within the yellow-red and red-firing color groups are more closely related than those in the buff-firing color group (Figure 21). Most noteworthy is that nearly 100 percent of the gray ware sherds are within the buff-firing color group. A one-way analysis of variance test (ANOVA) confirms that the mean difference between sherds in the yellow-red and red firing groups versus those in the buff-firing groups is statistically significant (*F=11.00, d.f.= 236, p=.00*), primarily driven by the difference between brown and gray ware. Therefore, these data coupled with the refired apparent porosity measures support the interpretation that brown and gray ware vessels were manufactured using different raw materials.

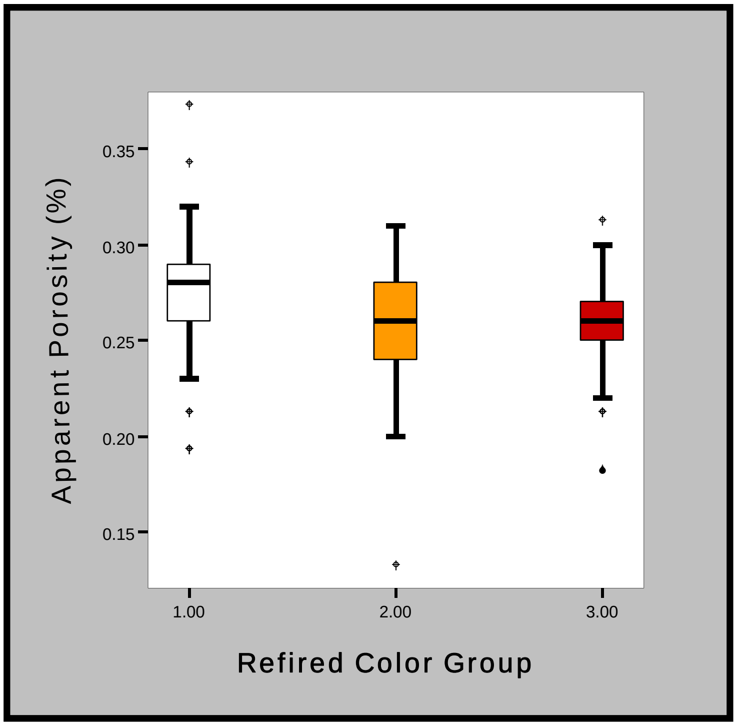


Figure 21. Refired Apparent Porosity by Color Group.
(Group 1=Buff, 2=Yellow-Red, 3=Red)

Table 9. Summary of Descriptive Statistics for Unrefired and Refired Apparent Porosity, Brown and Gray Ware.

	Unrefired Apparent Porosity	Refired Apparent Porosity
Brown N	326	326
Brown Min	7.2	8.1
Brown Max	52.3	36.6
Brown Mean	19.6	21.5
Brown Standard Deviation	3.3	2.5
Gray N	142	142
Gray Min	9.7	12
Gray Max	46.6	59.8
Gray Mean	22.6	23.5
Gray Standard Deviation	4.1	5.1

Lastly, temper analyses of brown and gray wares were conducted (Elkins et al. 2006a, b). Studies consistently show differences between the temper used in brown and gray wares. Gray ware sherds tend to have metamorphic or granitic quartz temper, while the brown ware sherds contain sedimentary fluvial sand and igneous rock (Garrett 1987:159). Rugge (1985:147-148) notes that fluvial sands are the most common temper type in brown ware throughout the Pueblo/Mogollon transition zone, and that sherd temper is more common in the north, while crushed rock is more common in the south. Inspection of ceramic pastes identified a number of tempering agents, such as water-worn and basaltic sands, crushed rock (possibly phaneritic igneous rock or granite), and crushed sherds. Of these tempering materials, Mogollon brown wares tend to have crushed rock and sand while gray wares generally contain either sand, sherd or both (Figures 22, 23). The temper analyses indicate that gray and brown sherds were tempered differently, reflecting different production techniques.

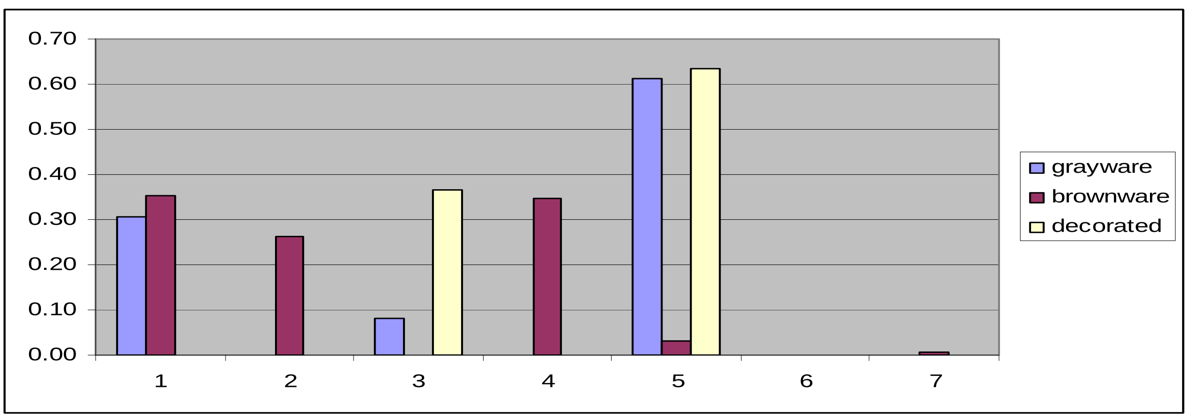


Figure 22. Percentage of Each Temper Recipe Type for Gray, Brown, and Painted Wares.

1	Sand only
2	Rock only
3	Sherd only
4	Sand/rock
5	Sand/sherd
6	Rock/sherd
7	Rock/sand/sherd

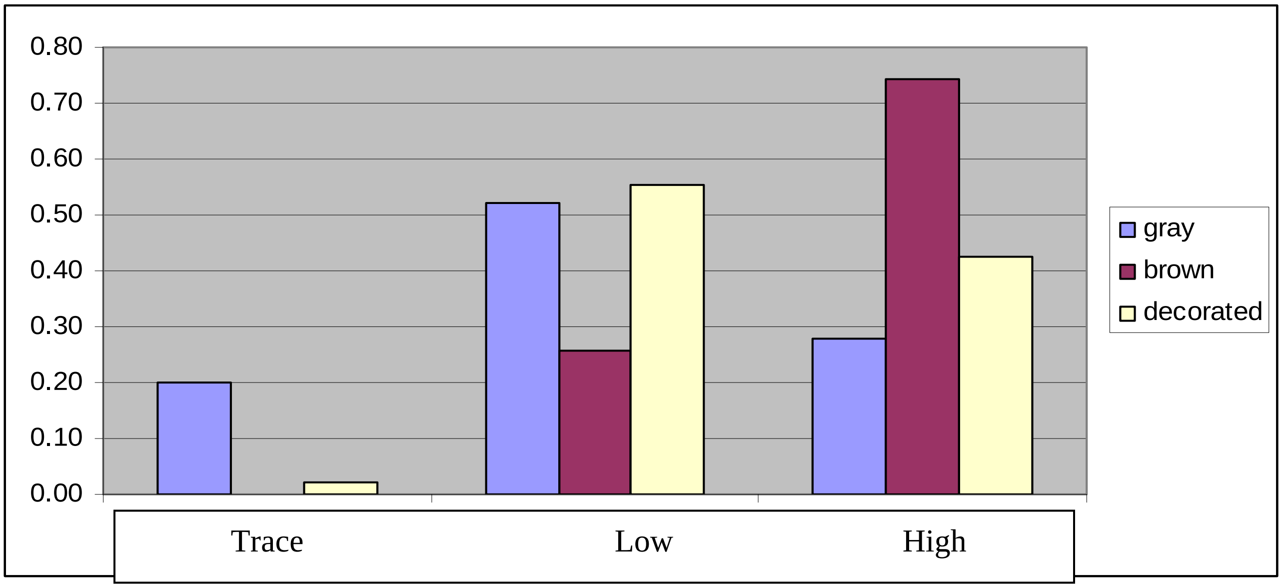


Figure 23. Percentage of Temper Added for Gray, Brown, and Painted Sherds.

The data presented here illustrate that brown and gray ware ceramics at Cox Ranch Pueblo were visually and technologically different, and were manufactured using different clays. The measures of unrefired apparent porosity are different for brown and gray vessels. This may indicate that they served different functions, however both lie within the accepted range for cooking vessels. In addition, observations of refired paste color and refired apparent porosity indicate that these vessels were manufactured from different raw materials, all of which appear to have been available relatively near the site (Duff and Nauman n.d.). Furthermore, temper analyses also indicate differences. Previous studies of physical attributes of the sherds, including the thickness of coils, the number of indentations per square centimeter, thickness, and paste, also indicate significant differences between these two wares at Cox Ranch Pueblo (Duff and Nauman n.d; Nauman 2007). Differences in the combined suite of vessel attributes indicate that people from two different historical traditions or learning frameworks were responsible for the manufacture of brown and gray ware vessels at Cox Ranch Pueblo.

Brown and gray ware sherds co-occur in all areas of the site, in all middens, and the range of clays used to make these vessels is available locally (Duff and Nauman n.d., Nauman 2007). Therefore, the residents of Cox Ranch Pueblo were not only building their pots differently, they also were making distinct choices about their materials for pottery manufacture. This study of ceramic technological style lends support to the idea that the residents of Cox Ranch Pueblo came from areas both north and south of the site, co-residing for a few generations. The undecorated ceramics evidence these blended histories at a site which also exhibits some affiliation with Chaco Canyon. Cox Ranch Pueblo exhibits a Chacoan architectural pattern related to the Colorado Plateau and a dominant utilitarian technological tradition of pottery manufacture with historical roots in the Mogollon culture area.

There is no within-site variability for the locations of brown and gray ware—Mogollon and Pueblo people were not segregated to specific roomblocks or areas of the site, therefore co-residence was likely characterized by extensive interaction. Although the clays needed to manufacture both brown and gray ware are available locally, the possibility that gray ware was imported into the site cannot be completely ruled out without chemical characterization of the clays. When brown and gray ware from Cox Ranch is compared, gray ware constitutes about 19 percent of the assemblage. Using the amount of imported ceramics at Chaco Canyon proper as comparison, we can see that the Cox Ranch percentage is slightly higher on average than would be expected if gray ware was an import. Based on surface and temper characterization, imported red, white, and brown smudged ware in Chaco Canyon averages about 10 percent of total ceramics for all time periods (Toll 1991:94, Table 5.2). In the early history of Chaco (pre-A.D. 900) imported ceramics are less than five percent, but reach their highest between A.D. 1040 and 1100 at 25% of the total assemblage (Toll 1991:93-95). Furthermore, in general at

Southwestern sites, utilitarian jars such as gray ware are manufactured locally for household consumption and rarely imported. The Chaco Canyon data reflect this assumption, with decorated wares (red, white, and brown smudged) constituting 70 percent of the total imports and gray ware constituting 30 percent, although it appears that trachyte-tempered gray ware from the Chuska Mountains was highly valued at Chaco (Toll and McKenna 1997:131, Table 2.58). Closer to the study area in the Fence Lake Coal Lease areas of Carrizo Wash Valley, New Mexico and near St. Johns Arizona, qualitative data based on petrographic analyses and oxidation studies lends support to the assumption that sites in the region were characterized by local ceramic production (Crown 1981; Hagopian et al. 2004; Mills 1987). Furthermore, Cox Ranch and Cerro Pomo appear to have very little imported material in general (nonlocal lithics, turquoise, shell, etc).

This case study of brown-gray technological style is relevant because it serves as a backdrop for further research questions regarding Pueblo and Mogollon identity as expressed in ceramics. In particular, it confirms that fact that two distinct pottery learning frameworks were present at Cox Ranch Pueblo and that the Mogollon tradition was dominant. Since this is the case, it follows that a similar pattern would be present in the decorated wares, particularly between the White Mountain Red Ware sherds which are likely a Pueblo tradition, and the smudged brown ware sherds which are distinctly Mogollon. As I have shown (see Chapter 4), the distribution and in-site frequencies of red painted versus brown smudged ware do mirror the brown-gray pattern–brown ware is dominant over red. If the Mogollon pottery tradition is dominant in the decorated and utilitarian wares, this has implications for the social organization of Chacoan great houses like Cox Ranch Pueblo. Specifically, Mogollon brown smudged bowls may be being used in the place of White Mountain Red Ware bowls. To test this hypothesis, I must establish that brown smudged and red painted bowls are functionally similar, and that smudging is a decorative technique that could be as highly valued as painted ware and similarly imbued with style. An explanation of the smudging technique and its importance through time is given in the following chapter to bolster the argument that smudged bowls were recognized by both their makers and audience as a distinctly Mogollon decorative treatment.

CHAPTER 7
UNPAINTED BUT STILL PRETTY:
BROWN SMUDGED AND RED WARE BOWLS

I argue in this chapter that the technique of smudging on Mogollon Brown Ware is decorative, rather than functional. Furthermore, the residents of Cox Ranch, Cerro Pomo and surrounding communities chose to use smudged brown ware rather than red painted ware as decorative serving bowls. As a means of decoration, smudging communicates style unique to people with Mogollon roots. This style was widespread in the Southwest, but the intensive use of smudged ware instead of red painted ware was more specific to the local tradition represented in west-central New Mexico, possibly beginning in the Pueblo II-III time periods.

So, if smudging on brown ware is a stylistic technique and smudged brown vessels are used in contexts similar to painted vessels, we would expect there to be a large number of smudged sherds relative to painted sherds in site assemblages. This expectation also implies that the Mogollon population is dominant in these sites. In fact, this is true at Cox Ranch and Cerro Pomo Pueblos when we compare specifically the numbers of smudged brown ware bowls to red painted bowls (see Chapter 4). These assemblages are almost completely devoid of painted red ware sherds. In contrast, sites north of the study area exhibit much larger numbers of red painted ceramics. As I have shown, the north-south pattern of Mogollon brown-to-Pueblo red ceramic ratios holds when we examine a larger distribution of sites in west-central New Mexico and east-central Arizona (see Chapter 4, Figures 14 and 15).

My argument for smudging as a decorative style which serves a social function rests on the observation that at Cox Ranch and Cerro Pomo Pueblos, smudging occurs almost solely on the visible interior of bowls rather than cooking jars, and that plain brown bowls could just as easily serve the same functional purpose, but they are present in very low numbers, if at all, at these sites. The firing process that produces smudged vessels is more labor intensive as well. Furthermore, in numerous site assemblages, smudging becomes more popular through time and is associated with a variety of exterior corrugated and painted surfaces which are likely decorative (Haury 1936; Martin 1952; McGimsey 1980; Rinaldo and Bluhm 1956). Utilitarian pots exhibit a wide variety of exterior corrugation types that I would argue have both functional and stylistic components. While experimental studies have indicated that corrugated exteriors on cooking pots help to reduce thermal spalling, increase surface area, and improve a pot's "graspability" (Schiffer 1988), the many variations on the corrugated theme could only be decorative. The Cox Ranch and Cerro Pomo smudged brown wares exhibit a wide range of exterior surface treatments including plain, indented, incised, and patterned corrugation, sometimes accompanied by scoring and punching. This is in stark contrast to the gray wares, which are largely one of two types: plain or indented corrugated. This may further attest to the status of smudging on brown bowls as decorative.

In the following, I present a description of Mogollon Brown Ware types, the smudging process, and their distribution and variability through time, followed by a discussion of White Mountain Red Ware. I emphasize that smudging is a decorative technique and that it first becomes prevalent during the Pueblo II period, when Cerro Pomo and Cox Ranch Pueblos are occupied. White Mountain Red Ware, on the other hand, was locally produced in small numbers and was less important to the residents of Cox Ranch and Cerro Pomo Pueblos when compared to other sites to the north.

The Smudging Technique

Little research has been done on the technique of smudging in ceramics, how it is accomplished, and what function it has. Smudged vessels are so-called because they exhibit a shiny black surface; the degree of luster depending on the degree of polishing of the vessel's surface. The vessel color will vary from a matte black to near silver depending on the amount of smudging and polishing. There are two possible ways that smudging is accomplished which involve either the firing technique (Rice 1987:158; Rye 1981:108; Shepard 1980:88) or the chemical composition of the slip which is applied to the vessel prior to firing (Lyon 1988).

Modern Native American groups practice smudging, particularly in the Santa Clara and San Ildefonso Pueblos, where potters produce vessels with highly lustrous exteriors (LeFree 1975). An open fire is smothered with a dense layer of fine organic material, such as manure, sawdust or pine needles. This cuts off the oxygen to the pots, and causes the temperature to drop. Other material, often scraps of sheet metal for modern groups, at first protect the pots from direct contact with the organics. The sheet metal is removed, and the organic material is pushed in closer to the vessels so that sooty smoke settles on the pots, causing the carbon to penetrate the pores. On highly polished vessels, this results in a permanent shiny, black to silver color. The time for this portion of the firing can vary from 15 minutes to an hour, but the luster will be impaired if the fire temperature is too high (Shepard 1980:88). Experimental studies (Schiffer 1988, 1994) have recreated the smudging technique in an aluminum kettle with a fine layer of sand at the bottom and a small amount of dry pine needles. A vessel was fired in a kiln, removed at 500 degrees Celsius during cool-down, and placed face down over, but not touching, the pine needles. The hot pot creates a seal against the sand, and its heat ignites the pine needles, resulting in a reducing atmosphere and abundant smoke that deposits the organic matter onto the vessel surface (Schiffer 1994:202). In the Philippine village of San Juan Bautista, potters make cooking jars with an iron-rich slip and smudged exteriors by firing them and immersing them in a bed of rice chaff while still hot (Longacre et al. 2000). These smudged vessels are highly valued by consumers at the local market for their striking appearance and may be slightly stronger due to their surface treatment.

Achieving smudging on the interior of a vessel only, as is the case with Mogollon smudged brown bowls, is more difficult and requires more steps. Intentional smudging requires more time and investment than the firing of other plain ware vessels. "The vessels and the surrounding fuel of dry dung must be so placed, and the fire must be so controlled that, while perfect combustion takes place, high temperatures shall not develop too quickly" (Curtis 1926 cited in LeFree 1975:66).

Alternatively, Lyon (1988) has shown that the chemical composition of the slip applied to a pot may be more responsible for smudging than smothering them during firing. According to Lyon, Southern Tewa potters (San Ildefonso and Santa Clara Pueblos) use a slip containing ferric oxide which produces a rich red color when fired in an oxidizing atmosphere, and a lustrous black color when fired in a reducing atmosphere. A chemical change results in the conversion of hematite in the clay to black magnetite (Lyon 1988; Peckham 1990:125). This is especially intriguing if prehistoric potters also used a particular type of slip whose color was dependent on firing technique, because it would further indicate that potters' chose to make smudged ware rather than red-slipped ware.

Chronology of Smudged Ware

The smudging technique occurs relatively late in the sequence of Mogollon Brown Ware types and seems to gain popularity through time. The manufacture of Mogollon Brown Ware began as early as A.D. 300 with "Alma Plain" and gained popularity through time, found at sites as late as A.D. 1450 (Table 10, Hays-Gilpin and Hartesveldt 1998; Peckham 1990).

Table 10: Dominant Reserve Brown Ware Types in the Southern Cibola Region

Type Name	Date Range	Example	Type Name	Date Range	Example
[1]Alma Plain (also Neck-Banded, Incised and Punched varieties)	A.D. 300-900		[2] Tularosa Patterned Corrugated, (plain and smudged)	A.D. 1050-1250	
[3]Reserve Plain and Smudged	A.D. 900-1125		[4]Starkweather Smudged	A.D. 950-1200	
[5]Reserve Plain Corrugated, Incised Corrugated, Punched Corrugated, and Indented Corrugated (Smudged varieties of all)	A.D. 900-1125		[6]McDonald Corrugated Smudged	A.D. 1200-1250	
[7]Reserve Tularosa Fillet Rim (nearly always smudged)	A.D. 1100-1250		[1-7]Photo Credits (left to right)	[1]Western New Mexico University, Silver City [2]UNM Maxwell Museum, Albuquerque [3]Field Museum of Natural History, Chicago	[4-6]Laboratory of Anthropology, Santa Fe [7]UNM Maxwell Museum, Albuquerque

However, by the late Pueblo II period and most certainly after A.D. 1125, most plain and corrugated brown bowls are smudged (McGimsey 1980). Reserve Smudged is the brown ware type prevalent in the Southern Cibola region that has several sub-types (corrugated, punched, incised, and patterned) with a wide production range from about A.D. 900-1250 (Hays-Gilpin and Hartesveldt 1998:148; Logan Museum at Beloit 2007; Rinaldo and Bluhm 1956). Table 9 summarizes the main Reserve Brown Ware types relevant to the study area, and illustrates the florescence of smudged varieties with both corrugated and painted exteriors after A.D. 900.

Rinaldo and Bluhm (1956) see an evolutionary trend in brown ware where Reserve Smudged is a late interior-smudged version of Alma Plain, and black-on-red decorated interiors replace smudged interiors later in time. In other words, through time, plain brown ware becomes more sophisticated with the addition of smudging and painting. Haury (1936) goes so far as to see all surface treatments such as smudging, incising, punching, polishing, scoring, and neck banding as Mogollon techniques rather than Puebloan. Mogollon pottery is a close-knit technology because the painted-decorated types are more closely related to the plain ware types, and they exhibit combinations of paint, texturing, smudging, and corrugation; whereas there are sharper contrasts between these techniques in the Pueblo tradition (Haury 1936:155).

The smudging technique seems to be associated firmly with the Pueblo II period, and smudged vessels are common after that point in time. Prior to Pueblo II (pre-A.D. 900) plain brown ware is ubiquitous in Mogollon sites, but smudging has not been identified. In his trait list of Mogollon culture in the Reserve area of New Mexico, Martin (1952:492) shows that smudged ware does not appear until the San Francisco Phase (A.D. 900); earlier phases (A.D. 300-900) exhibit only plain brown ware. Similarly, Alma Plain Brown Ware is found in the early portions of the SU site in New Mexico, but no smudged sherds of any type are present. In contrast, the later structures, which make up a significantly smaller portion of the site, contain Reserve Smudged Brown Ware (Johnson 1967:368-369). Later sites such as Broken K Pueblo in Eastern Arizona (A.D. 1150-1280, Martin 1967:139) are associated with later painted types such as St. Johns Polychrome, and smudged bowls represent over 16 percent of the total (all forms) of plain and corrugated pottery (Martin 1967:138).

Later in time some smudged vessels exhibit painting and slipping on corrugated exteriors. For example, McDonald Corrugated (A.D. 1200-1250) exhibits corrugated exteriors with geometric white-painted designs and smudged interiors, akin to the contemporaneous White Mountain Red Ware type of St. Johns Polychrome. Starkweather Smudged (AD 950-1250) (Figure 24), found in the upper San Francisco River, Tularosa River, and Apache Creek areas of New Mexico is a particularly interesting example of the combination of painting and smudging on bowl interiors (Haury 1936:122, 173). Apparently, the interiors of these vessels were painted in white, then polished over and fired in an oxidizing atmosphere, nearly completely obscuring the painted design. Designs appear because of contrast between the polished body of the pot and the non-polished painted area, a result similar to negative painting techniques (Rinaldo and Bluhm 1956:171).

Figure 24. Starkweather Smudged Bowl, Laboratory of Anthropology, Santa Fe

Smudged Ware Provenience

If Brown Smudged Ware has a special use or particular function, then we might expect to find it in specific contexts in sites. However, at Cox Ranch and Cerro Pomo Pueblos, both brown smudged and red painted wares are found across the sites in most contexts (Figures 25 and 26, Appendix L). Brown smudged ware, in particular, is found in every area of both sites (Great house, great kiva, midden, and roomblocks), with exceptions being the Cerro Pomo possible great kiva and Cox Ranch Roomblock 15-1, both of which had limited artifact assemblages. Both red painted and brown smudged ware are absent from Cerro Pomo's great kiva, but few ceramics of any kind were found in this unit despite its over 2-m depth. Red painted ware (all forms), on the other hand, has a more limited distribution at these sites. It is missing from the Cerro Pomo great house units 5 and 11, as well as from units 2 and 3 in Roomblock 2 of Cox Ranch. Overall, the largest number of sherds are located in the site middens, which is to be expected.

There are no clear intrasite patterns in location for brown smudged and red painted wares, other than that there seem to be no restrictions on where they were deposited, and presumably where they were used. This reinforces the fact that both brown smudged and red painted wares were used in similar domestic contexts, and brown smudged ware was particularly widespread. The few anomalies include Cox Ranch Midden 12, and Cerro Pomo great house units 10 and 13. Midden 12 of Cox Ranch stands out for its high numbers of brown smudged, and red painted ware numbers are relatively high in Cerro Pomo great house units 10 and 13 (n=45 and 35, respectively). There is variability in sherd numbers in the great houses of both sites; however the low numbers of both ware types in the roomblocks of Cox Ranch is interesting and could warrant further investigation. It is important to note that differences in ceramic assemblages between the

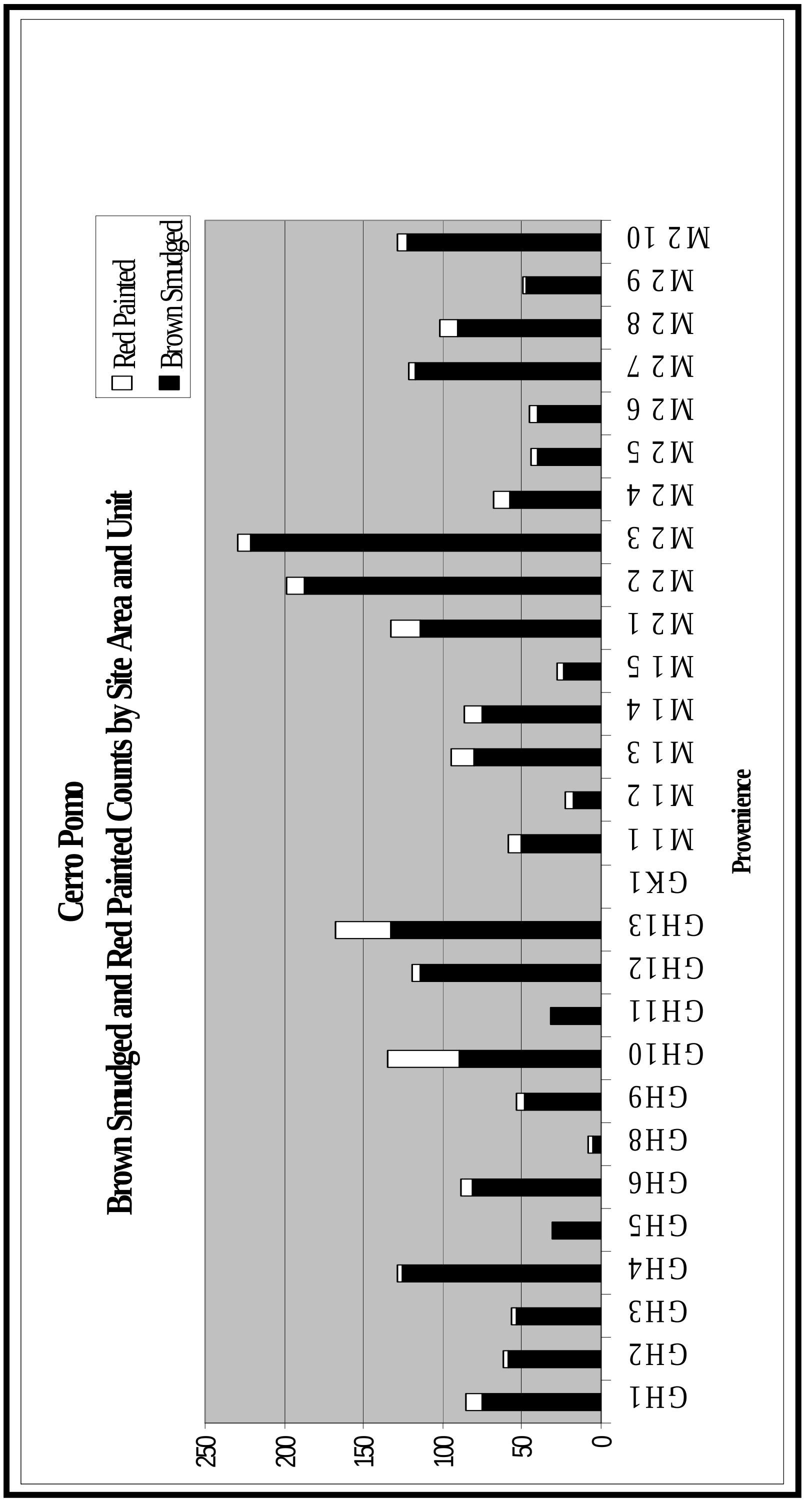


Figure 25. Cerro Pomo Pueblo: Brown Smudged and Red Painted Counts by Unit. GH = Great House, GK = Great Kiva, M = Midden. (There is no Great House unit 7).

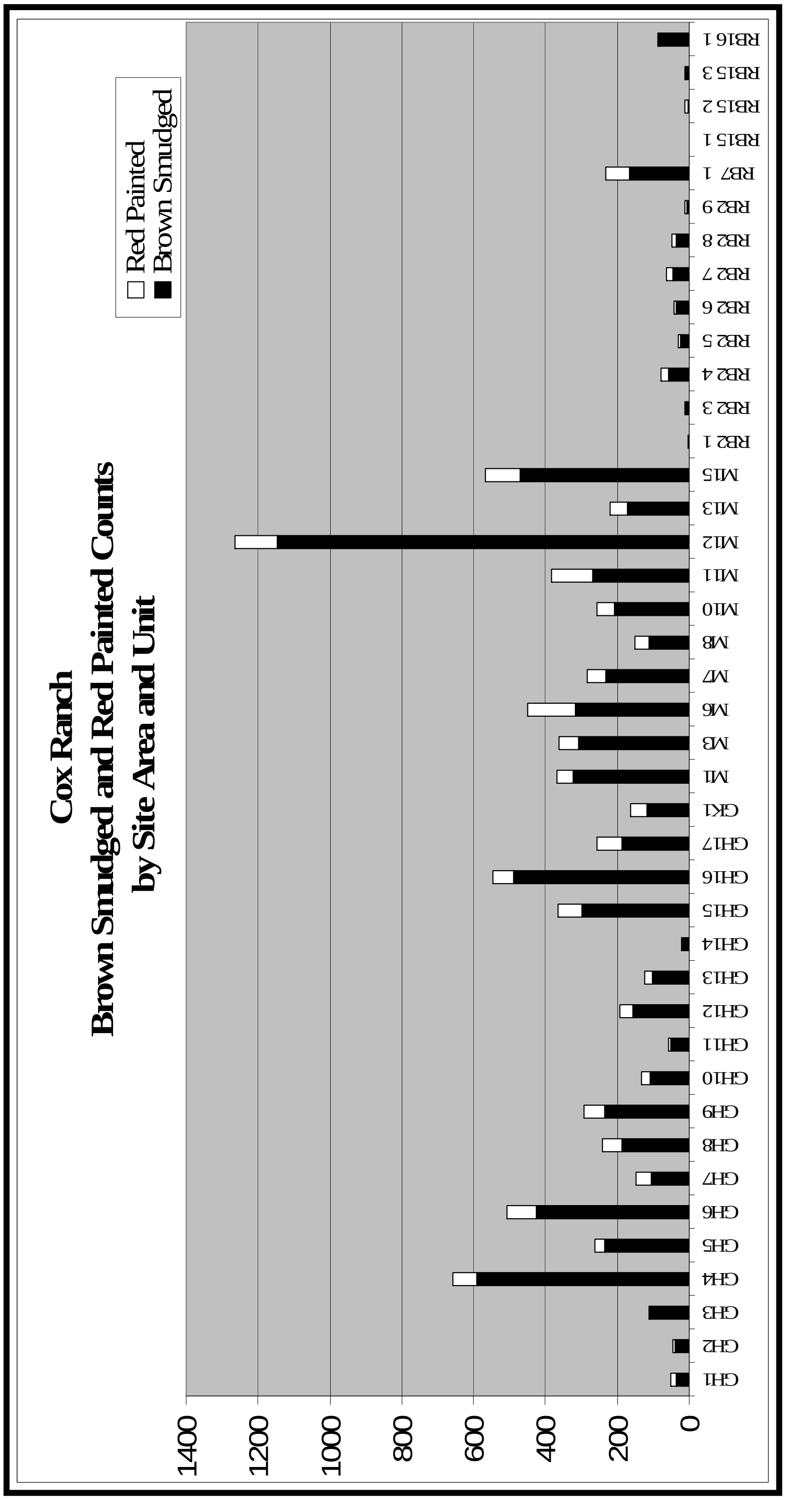


Figure 26. Cox Ranch Pueblo: Brown Smudged and Red Painted Counts by Unit. Area abbreviations are the same as the previous figure with the addition of RB (Roomblock). (Units within the middens are aggregated; Middens 2, 4, 5, 9, and 14 were not excavated).

two sites is largely due to the fact that Cox Ranch room interiors were mostly trash-filled; whereas the rooms at Cerro Pomo were largely cleared out and exhibited limited trash.

It is important to note that pottery can be used in domestic contexts as well as sacred ones. Vessels may serve in the daily tasks of cooking, storing and serving food, but also be used in religious ceremony (Rice 1987). This duality may also be one of public versus private where pottery vessels can be highly visible to large groups or noticed by only a small intimate group. These qualities apply to smudged vessels, which are found in a variety of site contexts from domestic to mortuary. Although we are unable to determine if smudged ware occurs in ceremonial or burial contexts at Cox Ranch and Cerro Pomo Pueblos, smudged ware is found often in burials in sites in east-central Arizona and west-central New Mexico (see Barter 1957:121 for Jewett Gap, Martin et al. 1949:205 for Oak Springs Pueblo, Rinaldo 1956:185 for Higgins Flat Pueblo).

Brown Smudged Ware Technology: Style or Function?

The technique of smudging may be either stylistic, functional, or both. Regardless of its function, smudging is overwhelmingly associated with brown ware and is thus a Mogollon trait (Crown 1984; Haury 1936; Mills 1987). Both brown ware and gray ware ceramics are often classified as utilitarian; used primarily for cooking. In contrast, decorated red and white wares are used as serving bowls and storage jars. Although a large proportion of brown ware is represented by cooking jars, I would argue that smudging on brown ware bowls is a stylistic, rather than utilitarian technique; and that brown smudged bowls were used for serving, similar to red painted bowls.

However, some research posits that smudging is a functional aspect of brown ware—a technique applied to improve the vessel's physical properties. Experiments on the effects of surface treatment have shown that smudged vessels crack less than those without surface treatment (Schiffer et al. 1994). Based on the fact that a vessel experiences high tensile stress on its interior during cooking, Schiffer et al. (1994:200) proposed that surface treatments are applied to improve a vessel's thermal shock resistance. Surface treatments reduce permeability, regulating both the flow of fluid from the interior to exterior of the vessel, and the way that heat is transferred from the fire to the interior surface during cooking. Smudged surfaces are low to moderately permeable, allowing the walls to become quickly saturated and promoting excellent thermal shock resistance but poor heating effectiveness (Schiffer et al. 1994:204). In experiments, hand-made pots were smudged, filled with water, and exposed to ten heating cycles after which the number of spalls and cracks were recorded. Smudging was only one of several surface treatments tested, and it represented a very small sample (3 vessels). These three vessels exhibited only slight cracking after the heating cycles.

In another experimental study, the abrasion resistance of several surface treatments including smudging were measured by weight loss of vessels after simulated abrasion in tumblers (Skibo et al. 1997). Abrasion, the scratching and pitting of a vessel's surface, can reduce heating efficiency and can be detrimental to a pot's use-life. Five hand-made smudged vessels were shown to be highly resistant to abrasion with virtually no weight loss.

Potters in a single neighborhood in the Philippines produce smudged cooking pots to market the pots effectively to consumers who readily identify them from a distance and perceive them to be more durable and resistant to failure (Longacre et al. 2000). Experimental studies with these pots did not show significant correlations between vessel strength and surface treatment, however those vessels with both red slip and smudging had increased heating effectiveness and water absorption. The authors cite these pots as a classic example of a visual performance characteristic (Schiffer 1992) that may have the “secondary result of slightly strengthening the pot, but whose principal performance characteristic is truly visual” (Longacre et al. 2000:277).

Thermal shock and abrasion resistance are important for cooking vessels, but smudging occurs almost exclusively on bowls. These properties could be important for serving hot foods in bowls, but to a lesser degree as cooking vessels are exposed to heat for much longer time periods. At Cox Ranch and Cerro Pomo Pueblos, smudging is found almost exclusively on bowls, not jars. Gray and brown ware utility jars are very rarely, if ever, slipped, painted, or smudged; and gray ware tends to be exclusively jar forms rather than bowls. However, during ceramic analysis some smudged jars may be incorrectly identified as bowls, since curvature can be difficult to assess on body sherds.

A preliminary look at the regional distribution of brown ware ceramics also shows it to be true that smudging was an important characteristic of brown ware bowls (Crown 1981:264 and Table 75). Mills (1987:112) states that smudged vessels are more often bowls and that the proportion of smudged versus unsmudged brown wares may indicate a special function for smudged vessels.

Although there are many factors affecting the validity of experimental studies in archaeology, these data can be very valuable. Future experimental studies of smudging alone with larger sample sizes could be very fruitful in determining the function of this surface treatment. Furthermore, although surface treatments can function to improve a vessel’s properties, given my current data set, it still seems more likely that the primary purpose of smudging was decorative.

Why then is pottery decoration important, and how could smudging be an important carrier of group identity? Answers to these questions are dependent on conceptions of style, which I have previously discussed (see Chapter 2), but briefly revisit here. Particular pottery styles can be used as carriers of social, political, or economic messages, or as markers of group affiliation that are recognized both by the people displaying the message and those receiving it (Wiessner 1984; Wobst 1977). The need for such messages arises as societies grow larger and more complex, with an increasing need for the members to convey information about themselves to others who may be physically or socially distant (Rice 1987:267). Furthermore, the role of artifact styles may be especially significant for symbolizing group identity when tensions exist between groups (Hodder 1979). The messages should be readily apparent visually and capable of being decoded by their audience. The simple but highly visible nature of smudging could make it a good candidate for a carrier of social information.

An important feature of all of the ceramic bowls at Cox Ranch and Cerro Pomo Pueblos, brown smudged and red and white painted alike, is that interior design is more important than exterior design. However, the difference between red and brown exteriors is also highly visible. Red and white painted bowls often have elaborate interior black-painted design with plain exteriors. Smudged bowls exhibit highly lustrous black interiors most often with plain exteriors, though some exhibit a variety of corrugated exteriors. The distinction between interior and exterior design on pottery appears to be sensitive to both time period and site context. The exterior surfaces of bowls became a design field in the prehistoric Southwest for the first time primarily during the later A.D. 1100s (Pueblo III); this is when the production of White Mountain Red Ware polychromes (vessels with interior design and exterior designs in different colored paints) become more popular (Mills 2007:215). This time period also corresponds to more aggregated settlements with the use of plaza space for ritual performance and feasting. Cox Ranch and Cerro Pomo Pueblos, on the other hand, are transitional sites (Pueblo II to early Pueblo III, A.D. 1050-1130) possibly occupied right before this shift, where interior pottery designs are important in conveying social information to small groups within the community. Interior designs are often important to the participants of ceremonies or feasts who are consuming the food, while exteriors are viewed by a much wider audience (Mills 2007:213).

Color in pottery design may also be symbolic and carry information about identity in certain contexts. Among the Mafa and Bulahay groups of northern Cameroon, an oil is used both to give some bowls a lustrous black burnish and to oil the body on festive occasions (David et al. 1988:371). The color black is seen as especially attractive to the ancestors who are invited to take part in sacrifices offered to them and in everyday meals. David et al. (1988:365) assert that the inter-relatedness of pottery decoration and symbolic structures justifies the widespread use of decoration as an index of ethnicity. They take this concept further by asserting that there is a direct relationship between the metaphor of the body and its adornment and pottery decoration (David et al. 1988:377). In an example specific to Southwestern pottery, Plog (2003) hypothesizes that hatchure design elements symbolize the color blue-green and in turn turquoise – a prized mineral in the prehistoric Southwest, whereas the color black in designs symbolizes the mineral jet. We can only guess as to whether or not the shiny black and silver hues achieved by smudging on Mogollon Brown Ware had direct symbolic importance; but it seems likely that as a whole this decorative technique carried meaning important to identity on a small community scale.

White Mountain Red Ware – Cibola's Red-Headed Stepchild?

The functional counterpart to brown smudged bowls in the Southern Cibola region may be red painted bowls assigned to the White Mountain Red Ware series, a name formulated for red-slipped ceramics in the upper Little Colorado region and on the Mogollon Rim of Arizona and New Mexico. Red painted ware is used widely in the northern Southwest as serving bowls, but as we have seen, it is conspicuously rare in the Southern Cibola region. The possible reasons for this distinct ceramic pattern are exchange of red ware from the north and/or the presence of a localized ceramic tradition signaling Mogollon ethnic identity. I contest that Mogollon potters had the knowledge needed to manufacture red painted bowls, but overwhelming chose to make brown smudged bowls instead. Mogollon Smudged Brown Ware serves as a marker of identity, and subsumes White Mountain Red Ware technology in the study area.

The production of White Mountain Red Ware dates roughly between A.D. 1000 and 1200 (Hays-Gilpin and Hartesveldt 1998:162) (Table 11). At Cox Ranch and Cerro Pomo Pueblos, the dominant White Mountain Red Ware types are Puerco Black-on-red (A.D. 1030-1150) and Wingate Black-on-red (A.D. 1050-1200). Wingate Polychrome (A.D. 1125-1225) is rare. White Mountain Red Ware most often occurs as bowls. It is made from light-firing clay exhibiting light brown to white paste, sherd temper, and a design style closely resembling that of Puerco Black-on-white and Reserve Black-on-white, the two most common white painted wares at Cox Ranch and Cerro Pomo Pueblos (Hays-Gilpin and Hartesveldt 1998; Mills 1987).

Although White Mountain Red Ware is rare at Cox Ranch and Cerro Pomo, it is a common decorative type for serving bowls during the Pueblo II and early Pueblo III periods in eastern Arizona and western New Mexico at sites above the Mogollon Rim, such as Sander's Great House, Zuni, and Fort Wingate, to name a few examples (see Chapter 3, Figures 11-12).

Table 11. Dominant White Mountain Red Ware Types in the Southern Cibola Region.
(Dates from Carlson 1970; Hays-Gilpin and Hartesveldt 1998)

Type Name	Date Range	Example	Photo Credit
Puerco Black-on-Red	A.D. 1030-1150		Santa Fe, Laboratory of Anthropology
Wingate Black-on-Red	A.D. 1050-1200		Santa Fe, Laboratory of Anthropology
Wingate Polychrome	A.D. 1125-1225		Santa Fe, Laboratory of Anthropology

Similar to smudged brown ware, red ware is a late development in the Southwest, mostly absent from sites prior to A.D. 1000. Furthermore, in the Pueblo III period and later (A.D. 1125 and later), White Mountain Red Ware numbers steadily increase, represented by Wingate and St. Johns Polychrome, and it becomes an important trade ware in sites above the Mogollon Rim (Marshall 1991; Mills 1987).

Most scholars agree that White Mountain Red Ware has a Pueblo origin. Carlson (1970:1) asserts that although the area is largely Mogollon early in time, it is largely Puebloan by the time White Mountain Red Ware becomes prevalent (A.D. 1000). However, as we have seen, the Southern Cibola region still has a very strong Mogollon material culture signature during Pueblo II and later. Furthermore, many local variants of red ware exist in the Cibola region. In the Puerco Valley to the west and north of the current project area, the local brown ware type is ancestral to the local red ware tradition (Hays-Gilpin and Hartesveldt 1998:47). Potters simply began adding red slip to sherd-tempered brown ware. These red-slipped brown ware ceramics often exhibit smudging (Woodruff Red and Showlow Red, A.D. 1000-1200+), and are not present to the north in the Mogollon geographic area or culture area. White Mountain Red Ware, on the other hand, is introduced about A.D. 1030, and differs from the local red ware in temper, slip, and paste. It is unclear if it is a trade ware, or is made locally (Hays-Gilpin and Hartesveldt 1998:137).

Brown and red ware pottery can have overlap in their general clay properties. Both are often produced from red-firing clay, but manipulation of the firing technique (oxidizing atmosphere) results in a stronger red paste color for red wares, onto which red slip and paint is applied (Hays-Gilpin and Hartesveldt 1998:136). White Mountain Red Ware is often manufactured from light-firing clays as well. The application of red slip makes the color of the core clay largely irrelevant. An early Mogollon pottery type, San Francisco Red, consists of red slip applied to brown pottery. However, Peckham (1990:78) believes that solid evidence to show that San Francisco Red was ancestral to White Mountain Red Ware is lacking, even though there is geographic overlap in the Pueblo and Mogollon provinces.

Many analysts claim that the paucity of White Mountain Red Ware in the southern Southwest is because of its importance as a trade ware from the north (Carlson 1970; Elyea et al. 1994). Furthermore, oxidation studies have shown White Mountain Red Ware clay to be very diverse in its physical properties, meaning it may have had several different production localities from which it was exchanged widely (Mills 1987:150; Hays-Gilpin and Hartesveldt 1998:162). However, at Cox Ranch and Cerro Pomo Pueblos, there is a good possibility that red ware was made locally because ample red-firing clays are available nearby (Nauman and Duff 2007 n.d.; McDougall 2007).

Nauman and Duff (2007) conducted oxidation analyses on a sample of brown, gray, red painted, and white painted sherds from Cox Ranch Pueblo as well as geological clays from up to 25 km surrounding the site. These studies found that the raw materials selected for vessel manufacture differed significantly—gray ware jars were generally made from buff-firing clays, and brown ware jars from yellow-red to red-firing (iron-rich) clays. In addition, Cibola White Ware and White Mountain Red Ware were manufactured from predominantly buff-firing clays. The preference for light-firing clays is likely the result of cultural tradition, because it is possible with the correct firing technique to produce gray and white ware from iron-rich clays.

Similarly, a sample of sherds from Cerro Pomo Pueblo subjected to oxidation analyses shows that clays that fire to any of the three color ranges (buff, yellowish-red, and red) are locally available, with red-firing clays dominant. Because all possible clay types are represented, it is unnecessary to posit that any one type was traded into Cerro Pomo from an outside source (McDougall 2007:12). Although some vessels may have been traded into the site, they could also have been locally made.

In sum, all of the clay types used to manufacture all possible ceramic wares were available within a few kilometers of Cox Ranch and Cerro Pomo Pueblos. Potters at these sites were familiar with the firing properties of several different clay types and made distinct choices about which type to use based on the desired end product. Without more accurate compositional analyses of the clays, it is not possible to definitively say that the sampled clay sources were used for pottery manufacture. However, given all of the clay choices available, Cox Ranch and Cerro Pomo potters were actively choosing to manufacture mostly brown ware.

The evidence indicates that both brown smudged ware and red painted ware could be manufactured locally at Cox Ranch and Cerro Pomo, but that brown smudged bowls were manufactured in higher numbers than red painted bowls (in an even distribution) across both sites. The idea that brown smudged ware, rather than red painted ware, is preferred in the southern Southwest is not a new one. Because of the lack of painted pottery in sites in the southern Cibola region of New Mexico, Peckham (1990:39) has suggested that the "polished black tradition" may have been a substitute for painted types of the Mogollon slipped tradition, and that the rare painted sherds are the result of limited trade. Similarly, The Logan Museum's website of ceramic collections (University of Beloit) states that "in the Reserve region, little painted pottery appears to have been made locally. Smudged pottery may have been the alternative service and table ware" (www.beloit.edu/~museum/logan/southwest/mogollon).

These explanations assume exchange of red ware, but if we assume that White Mountain Red Ware has a northern Pueblo origin but was made by local potters with a direct historical connection to this ceramic tradition, something that is reasonable based on the availability of clays, then ethnic co-residence of Pueblo and Mogollon people (already established by the brown-gray distinction), is reinforced. The high visibility of the more dominant Mogollon ceramic tradition at these sites was intentional, in that it is the result of emblemic style on the part of Mogollon potters. The need for this expression of identity could have been reinforced by increased migration of Pueblo people to the area during the Pueblo II-III transition. In order to further test this hypothesis, we must determine if brown smudged and red ware bowls were functionally equivalent. If Mogollon potters could just as easily make and use a red painted bowl as a brown smudged bowl but they did not, then this reflects a distinct choice in pottery manufacture. These analyses are conducted in the following chapter.

CHAPTER 8
DATA ANALYSIS: BROWN SMUDGED AND RED PAINTED VESSEL SIZE AND USE

This chapter presents the ceramic analyses conducted to determine (1) whether or not Mogollon Smudged Brown Ware bowls and White Mountain Red Ware bowls are functionally similar in terms of size and physical attributes, (2) whether these wares were used similarly in the context of serving bowls, and (3) whether they were manufactured from similar raw materials that were available locally. These research questions will help to assess whether or not the observed spatial patterning of technologically different red and brown ware ceramics in the same contexts at Cox Ranch and Cerro Pomo indicates that smudged brown ware is being intentionally used in the place of painted red ware, and is therefore a Mogollon ethnic marker.

The analyses utilize vessel diameter estimates from sherds and whole vessels, measures of apparent porosity, and protein residue analyses. For each of these analyses, the mean values of each attribute are compared between ceramic wares using a Student's *t*-test to determine whether they are statistically similar or different and as a result, whether red painted ware and smudged brown ware are functionally similar or not.

Vessel Size

One way to begin to answer the question of whether or not red and brown ware were functionally similar is by comparing vessel sizes, assuming that vessel form equates to function and that similarly sized vessels are used for similar tasks. Vessel size data was collected from rim arc analyses of 557 bowl sherds from Cox Ranch and Cerro Pomo (Appendix E), and diameter measurements of 228 whole bowls from museum collections representing sites throughout the Southern Cibola region (Appendix F). The rim arc sample includes sherds from Cerro Pomo and Cox Ranch Pueblo excavations in the Great House only.

As did Crown (1981:264), I defined sherds and whole vessels as smudged when they possessed interior blackening and intentional polishing. This differs from blackening alone, which is present on numerous sherds, but is likely an unintentional result of firing. Brown ware sherds from Cox Ranch and Cerro Pomo Pueblo overwhelmingly exhibit smudging on bowls rather than jars. In my analyses of whole vessel collections, I also found smudging on jar interiors to be extremely rare.

If both red painted bowls and brown smudged bowls are used for the same purpose, such as serving food, they should have a similar range of diameters. In fact, the Cox Ranch and Cerro Pomo assemblage has similar diameter measurements from rim arc analyses: the mean rim diameter for brown smudged sherds is 22.17 cm and that of red painted rims is slightly larger at 22.7 cm (Figure 27). The majority of brown smudged rims have a diameter range between 22 and 24 cm, whereas red painted rims range between 18 and 22 cm. In the original assemblage there were several brown rims with a diameter less than 10 cm. These likely represent miniature vessels, which have been noted as a distinct Mogollon culture trait (Haury 1936). These small rims were eliminated from the analyses with the reasoning that no miniature vessels were included in the whole vessel analyses either. Overall, brown smudged rims have a wider range of sizes, and this trend of variation in vessel size may indicate the overall importance of smudged brown ware in numerous contexts. Both the brown and red painted rims have cases that exceed 48 cm in diameter, representing large serving bowls. These size extremes represent small numbers of outliers in the distribution, however, with the majority of both red and brown rims falling within the 14 to 30 cm range.

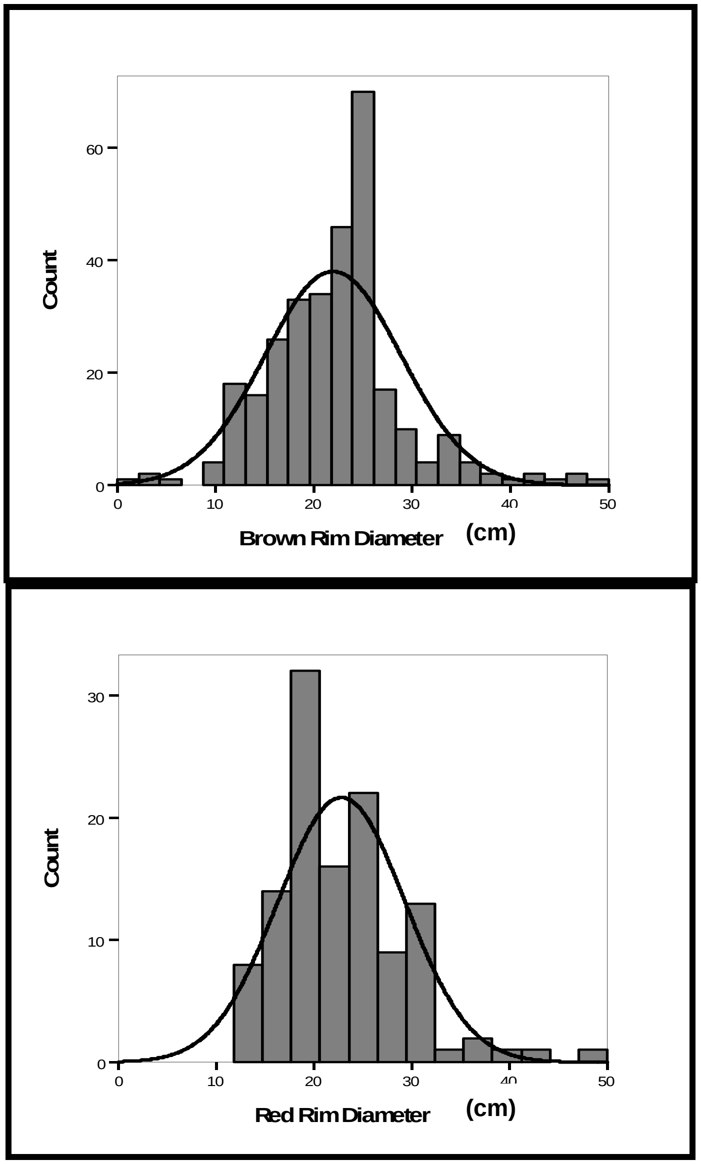


Figure 27. Estimated Diameter (cm) Distributions for Brown Smudged (top) and Red Painted (bottom) Bowl Rim Sherds.

An independent samples *t*-test confirms that red painted and brown smudged bowls were likely functionally similar based on diameter (Figure 28: $t = -0.863$, $df = 418$, $p = .389$). The mean diameters for both wares do not differ significantly, therefore it is unlikely that these two groups of sherds were derived from different populations.

The diameter of white painted rims was also included in this study as a control. Comparing the sizes of brown and red wares to white wares solidifies the argument that the two wares are similar and not just representative of the natural range of size variation for bowls. Interestingly, white painted rims have a slightly smaller mean diameter (20 cm) than red and brown rims (Figure 28). However, white painted rims also exhibit a wide range of sizes.

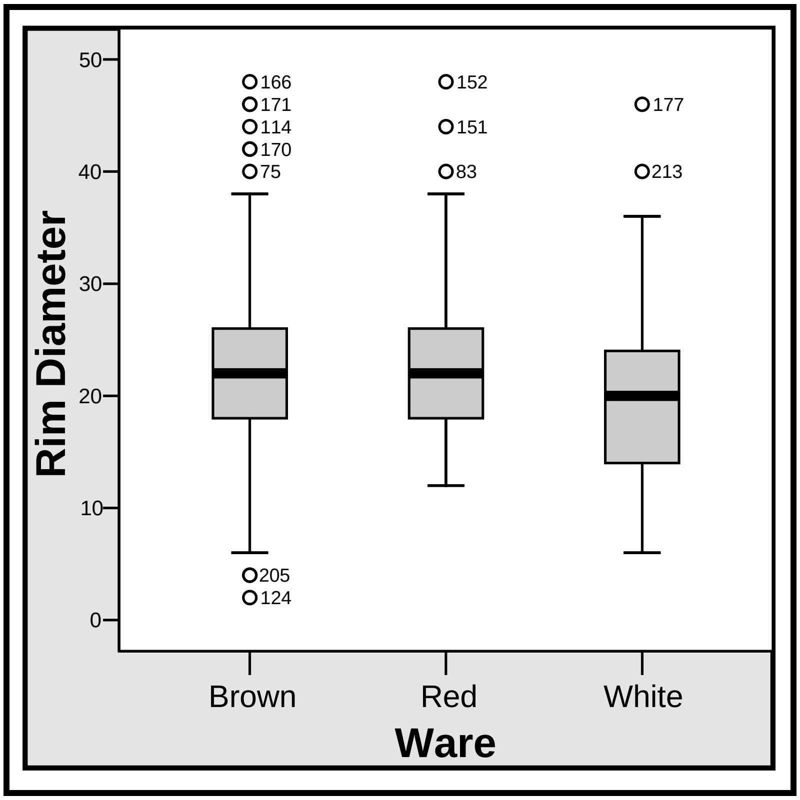


Figure 28. Estimated Diameter (cm) for Brown, Red, and White Bowl Rims – Cox Ranch and Cerro Pomo Pueblos.

To confirm the distinct mean size of white painted bowls in relation to brown and red bowls, an Analysis of Variance (ANOVA) test was conducted which confirms that the mean difference between the diameters of sherds in the red painted and brown smudged groups versus those in the white painted group is statistically significant ($F=1.7$, $df=560$, $p=.018$).

A comparison of 228 whole red painted, brown smudged, and white painted bowls from museum collections shows a similar, but not statistically significant range of vessel sizes: 22, 19.4, and 20.2 cm respectively (Figures 29, 30).

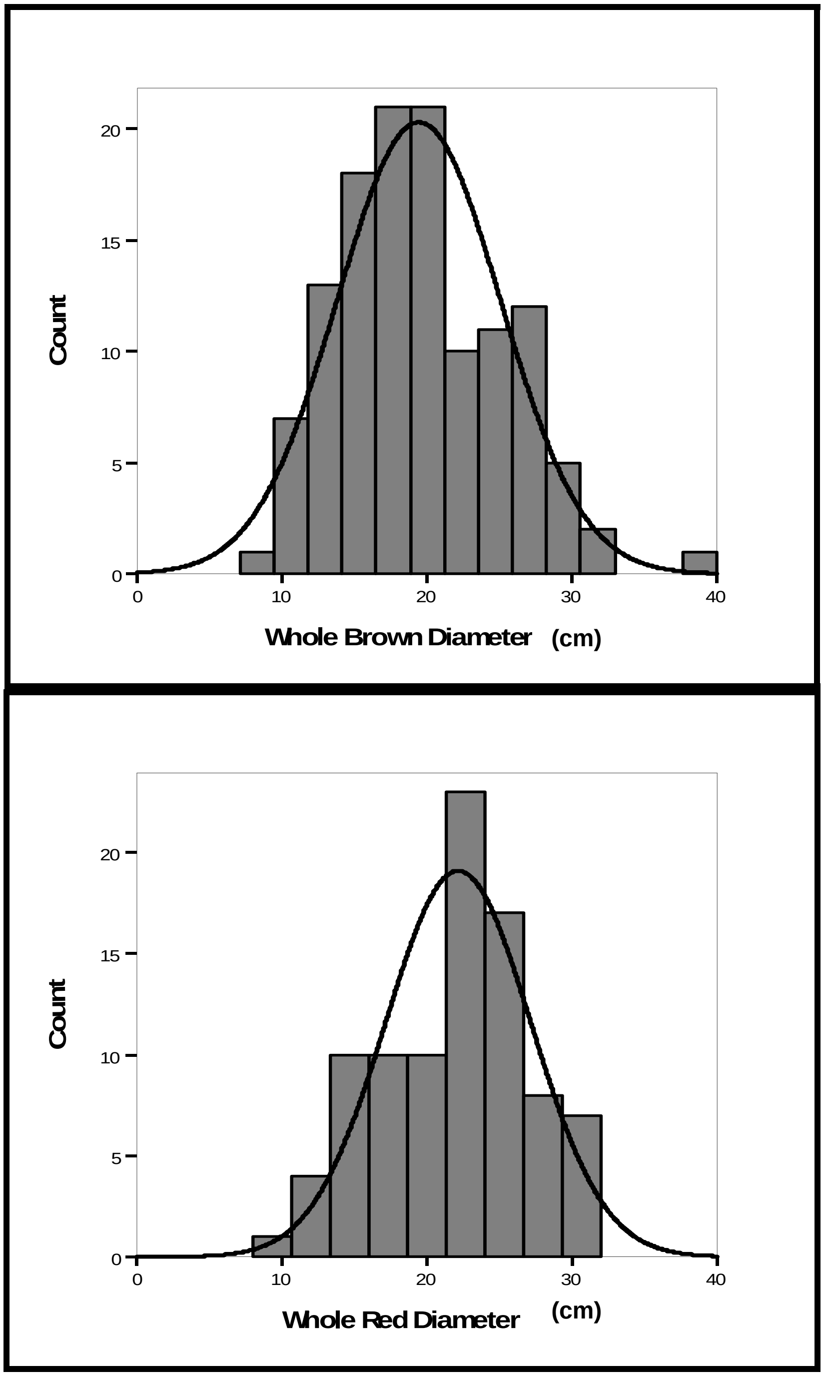


Figure 29. Rim Diameter (cm) Distributions for Whole Red (top) and Brown (bottom) Bowls.

Whole red painted bowl diameters range from 10 to 32 cm and brown smudged bowls range from 8 to 38 cm, with a high degree of overlap (Figure 29). Interestingly, in this sample, the mean diameters of brown smudged and white painted are more closely related than that of red painted and brown smudged. However, the white ware sample (n=16) is very small and cannot be used in statistical tests to confirm this.

An independent samples *t*-test indicates that the difference between the mean diameters of whole red painted and brown smudged bowls is statistically significant (Figure 31: $t = -3.6$, $df = 210$, $p = .000$) and that they did not likely originate from the same population. This outcome differs from that of brown and red sherd diameters, which were statistically similar. These results are interesting because I had expected size data from whole vessels to be more reliable and therefore more indicative of vessel function than that from rim arc. While this may still be true, I interpret these statistical differences as relating to variation within vessel use at the individual site level. My whole vessel data comes from a wide range of sites in the southern Cibola region, while the data for sherd diameter comes from Cox Ranch and Cerro Pomo great houses specifically. Within the larger distribution of sites, similarities between red painted and brown smudged vessel size may be obscured. However, the vessel size pattern at individual sites such as Cox Ranch and Cerro Pomo strengthens the argument that Mogollon potters were negotiating pottery manufacture choices at a local level among vessels perceived to be functionally similar.

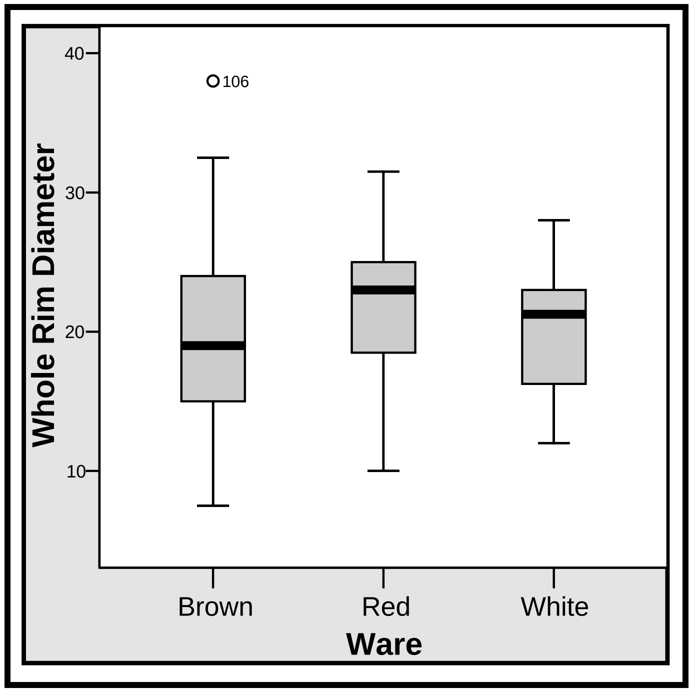


Figure 30. Whole Rim Diameter (cm) for Brown, Red, and White Bowls, Museum Collections

Overall, there appears to be a greater distribution of brown smudged vessel size than that of red painted. This may be due to sampling biases with the museum assemblages in particular, which could indirectly represent abandonment assemblages from the rooms of structures. Furthermore, there could be a greater chance of recovering variability within the brown smudged assemblage due simply to its large sample size. A final interpretation of interest could be that since brown smudged bowls appear in higher numbers than red painted bowls, they serve a wider range of uses.

Data for a suite of other whole red and brown vessel attributes were collected in this study including height, calculated volume, and rim thickness (Figures 31-33). Overall, comparisons of these attributes across wares indicate general size similarities, though brown smudged ware consistently exhibits a wider range of values than does red painted ware. The spike in brown vessel volume (Figure 32, top) is caused by a single very large serving bowl (121 cm^3) that likely had a specialized function.

Volume and height are additional measures of relative vessel size for comparison between red and brown wares, whereas vessel rim thickness, a possible proxy for wall thickness and thus the character of coils used in manufacture, may be indicative of how the vessels were built. As discussed in Chapter 5, volume was calculated with two formulas, one for a hemisphere and the other for a spherical segment. These will be referred to as volume 1 and 2, respectively.

Independent samples *t*-tests for these variables across wares indicate statistically significant mean differences for vessel height ($t=-3.3, df=210, p=.001$), calculated volume 1 ($t=-2.7, df=210, p=.006$), and calculated volume 2 ($t=-2.9, df=210, p=.004$). The similarity in *t*-test results for calculated volumes 1 and 2 indicate that either formula (see Chapter 5) is sufficient for volume estimation. However, brown smudged and red painted rim thickness exhibit statistically similar mean values ($t=-.812, df=208, p=.417$). Rim thickness values for red and brown wares are nearly identical (Figure 33; mean values of 5.6 and 5.5 mm). In contrast, the white painted wares exhibit much smaller rim thickness values (mean = 4.5 mm). Because of the small sample of whole white painted vessels, this difference cannot be statistically quanitified.

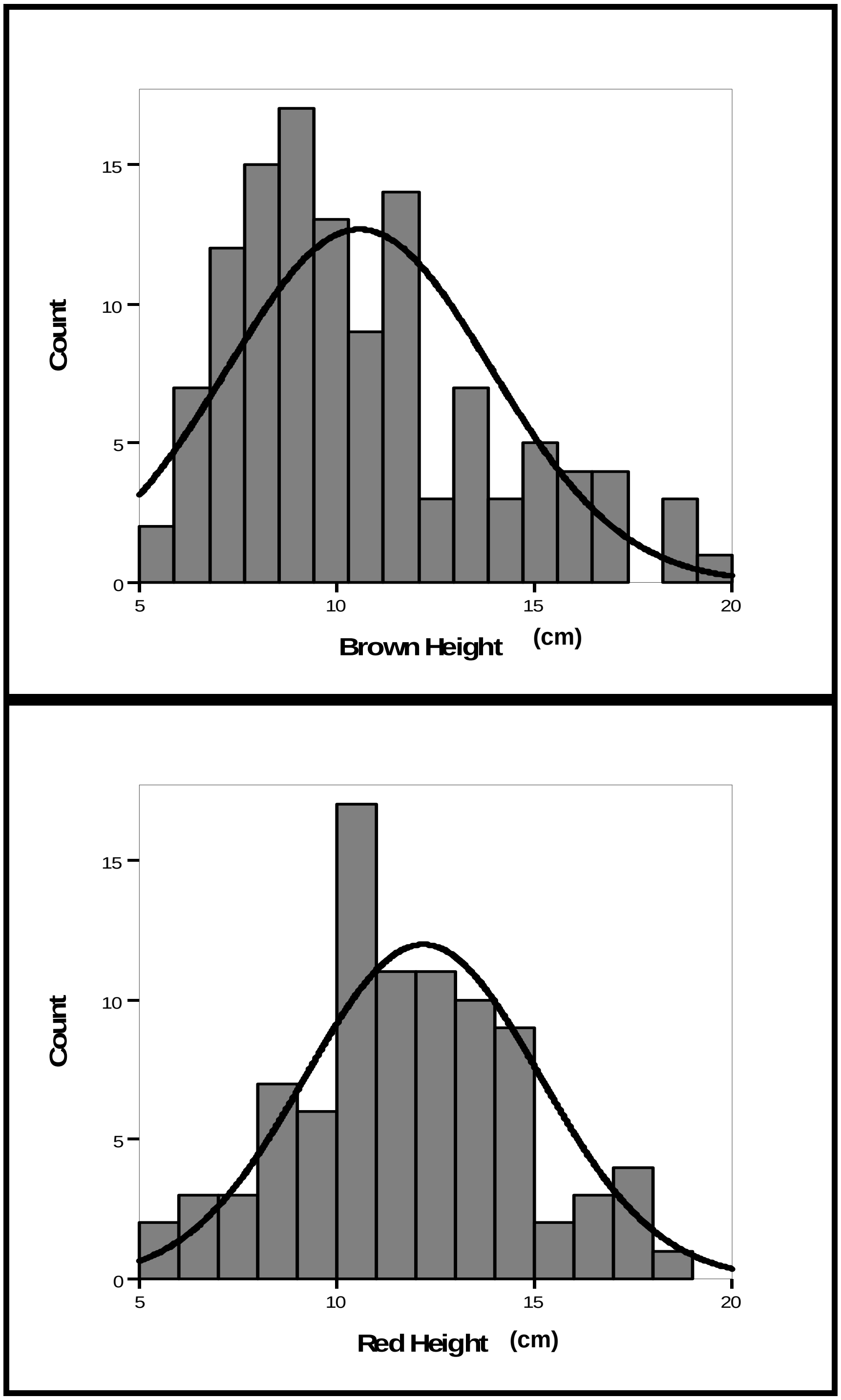


Figure 31. Histogram Comparing Brown (top) and Red (bottom) Whole Vessel Height (cm).

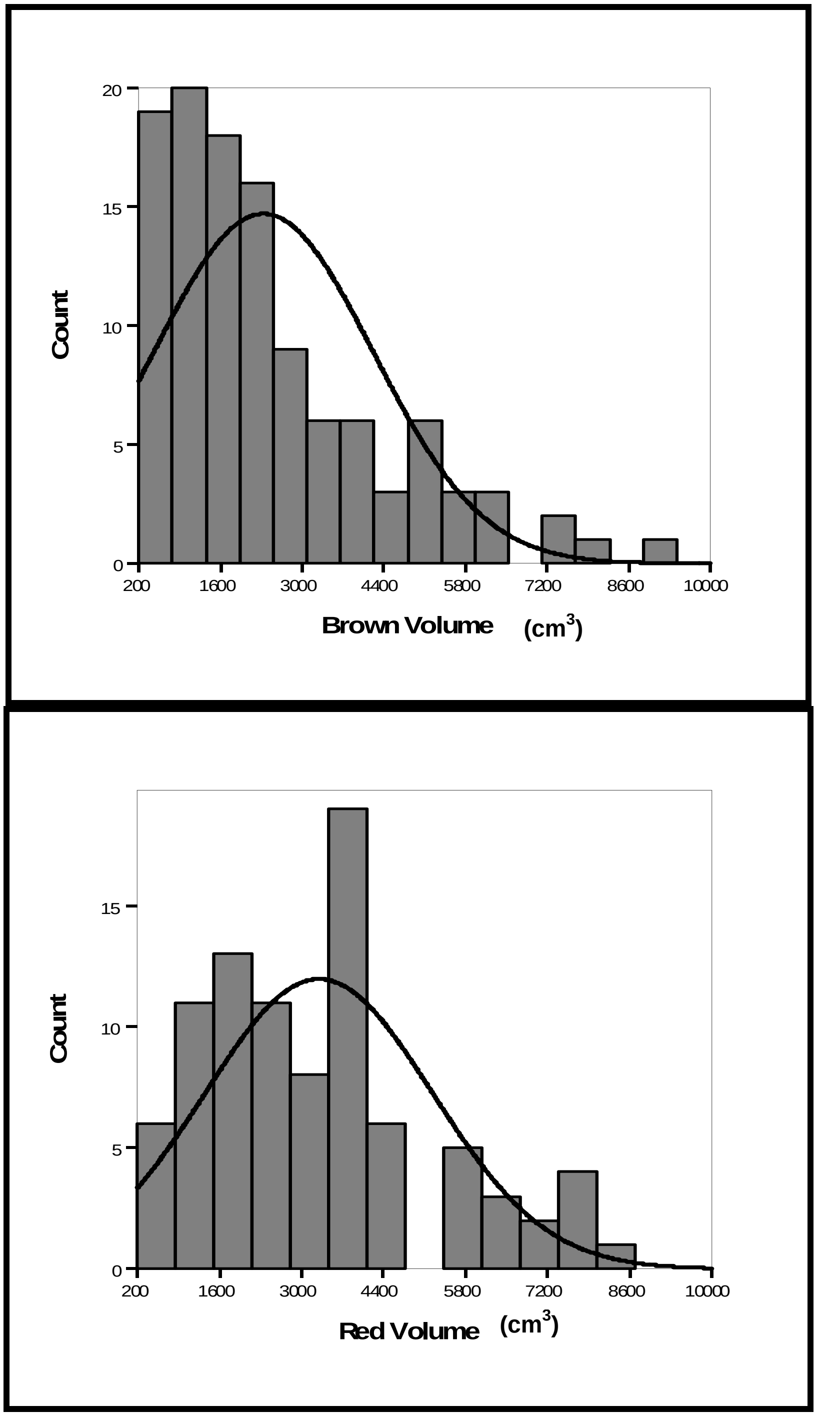


Figure 32. Histogram Comparing Brown (top) and Red (bottom) Whole Vessel Volume, Formula 1 (cm^3).

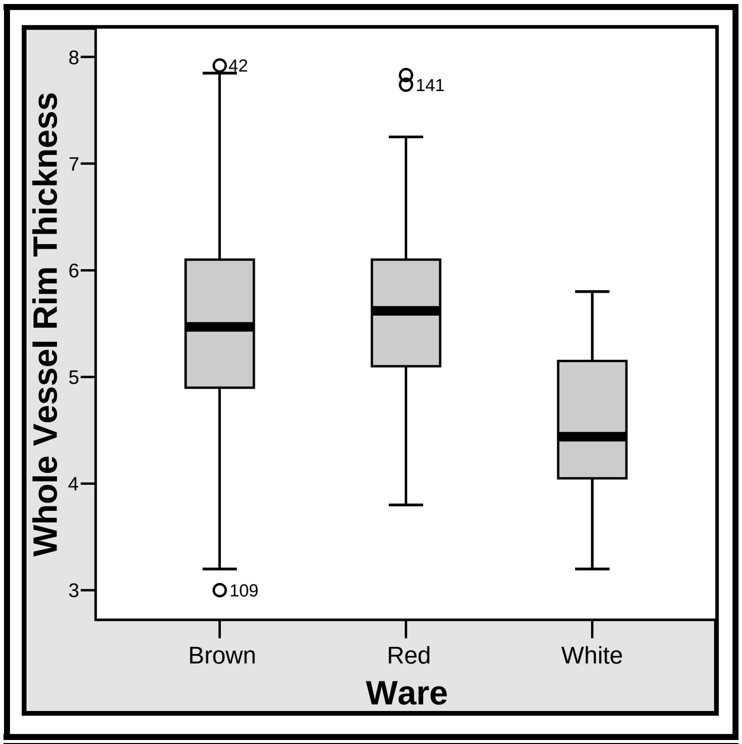


Figure 33. Mean Whole Vessel Rim Thickness (mm) for Brown, Red, and White Bowls.

These results could indicate that, on average, red painted and brown smudged bowls from sites throughout east-central and west-central Arizona were slightly different in size according to diameter, height, and volume, but were manufactured in a similar manner.

Porosity

The last variables to use for comparison between red painted and brown smudged wares are unrefired and refired apparent porosity values (Appendix H). These data can help to answer research questions about vessel function and raw material, respectively. Unrefired apparent porosity values for brown smudged bowls range from 8.5 to 25.6, whereas red painted bowls range from 14.4 to 34.7 (Figure 34). An independent samples *t*-test of brown smudged and red painted unrefired apparent porosity indicates that the mean difference across wares is statistically significant (*t=-13.2*, *df=286*, *p=.000*). Therefore, brown and red bowls may not have served the same function. However, the mean unrefired apparent porosity for painted white wares (21.7) is very similar to that of red painted wares (22.4). ANOVA confirms that the mean differences in unrefired apparent porosity between the red and white painted sherds and the brown smudged sherds is statistically significant (*F=94.3*, *df=342*, *p=.000*).

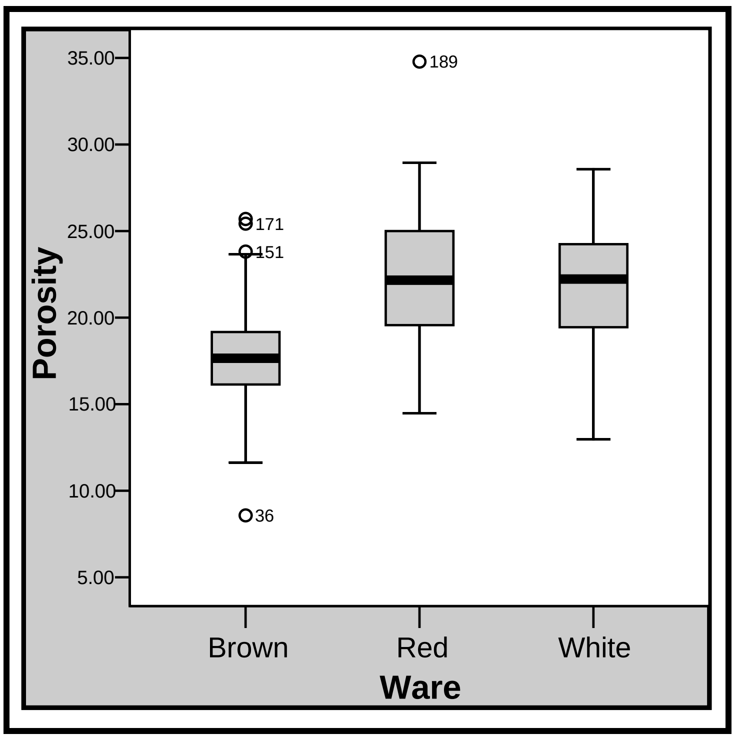


Figure 34. Mean Unrefired Apparent Porosity (%) for Brown Smudged, Red, and White Painted Sherds; Cox Ranch Pueblo.

Unrefired apparent porosity does appear to be measuring how the vessels were originally used, especially when we examine this data across vessel forms (bowls vs. jars). This becomes more apparent when we compare the mean unrefired apparent porosity values of brown smudged bowls likely used for serving food (17.7), with brown jars likely used for cooking (19.6) (Figure 35). Cooking vessels would inherently be more porous than serving vessels because high porosity, or high numbers of closed pores, increases resistance to thermal stress from cooking and heat conductivity in general (Shepard 1980). In fact, an independent samples *t*-test indicates that the mean differences between the unrefired apparent porosity of brown jars and brown smudged bowls is statistically significant (*t=7, df=510, p=.000*). The outcome is the same when the far outlier (observation 145 on Figure 35) is removed (*t=7.5, df=509, p=.000*).

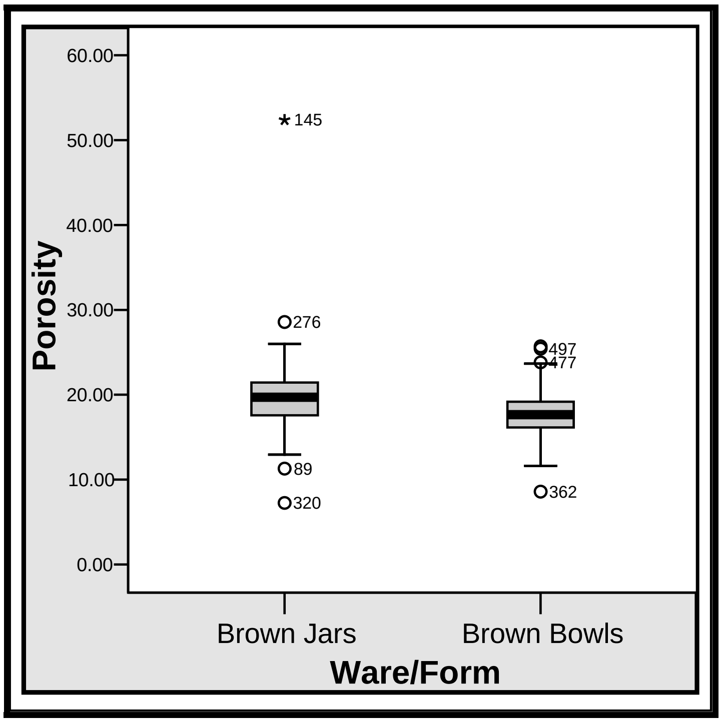


Figure 35. Mean Unrefired Apparent Porosity (%) for Brown Jars and Smudged Bowls; Cox Ranch Pueblo.

What are the ideal properties of a serving bowl? For the most part, a bowl would not need to be highly porous because it would not be exposed to direct heat. However, bowls often contain heated food and therefore good insulation would be desirable. A specific measure of insulation is the volume of open pores calculated by subtracting the sherd's dry weight from its saturated weight (Curet 1997) (Appendix H). Both brown smudged and red painted bowls have similar relatively high volumes of open pores (.34 and .35 respectively, Figure 36). In addition, both brown and red bowl distributions are highly right-skewed toward high open pore volume.

The mean differences of open pore volumes between brown smudged and red painted bowls are not statistically significant (*t=-.468, df=291, p=.640*). These results indicate that both brown and red ware bowls had statistically similar open-pore volumes, a measure of good insulation—a quality that may be more important for serving bowls than apparent porosity.

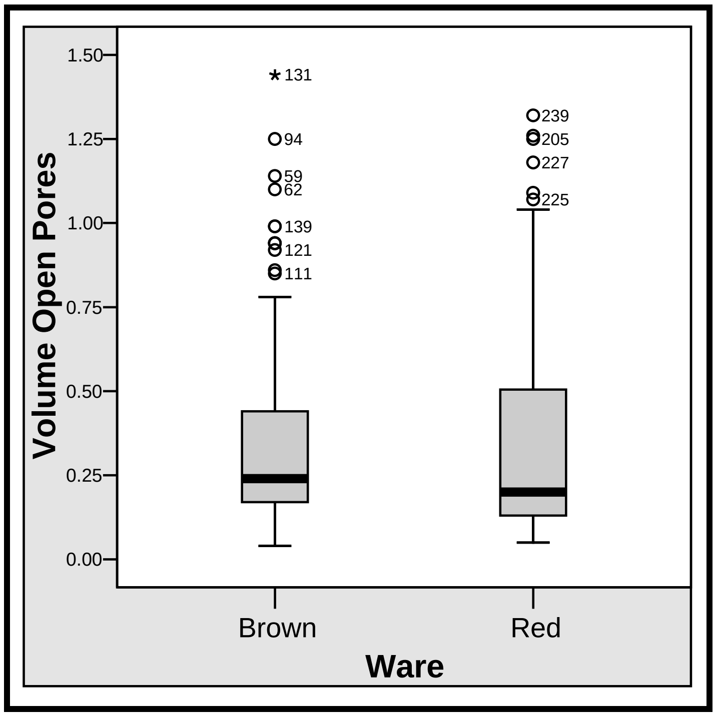


Figure 36. Mean Volume of Open Pores (Unrefired, cm^3) for Brown Smudged and Red Bowls; Cox Ranch Pueblo.

Lastly, I examine the values of refired apparent porosity, a measure of vessel raw material, for brown and red ware bowls. As previously discussed, these data measure raw material and temper rather than function because the measure is taken on sherds that have been refired, altering their clay properties. Refired apparent porosity values range from 10.9 to 42.9 for brown smudged bowls, whereas red painted bowls range from 14.8 to 29.8 (Figure 37) (Appendix H). An Independent Samples *t*-test of brown smudged and red painted refired apparent porosity indicates that the mean differences across wares is statistically significant (*t=-6.1*, *df=286, Sig.=.000*). This indicates that smudged brown ware and painted red ware bowls were manufactured from different clays.

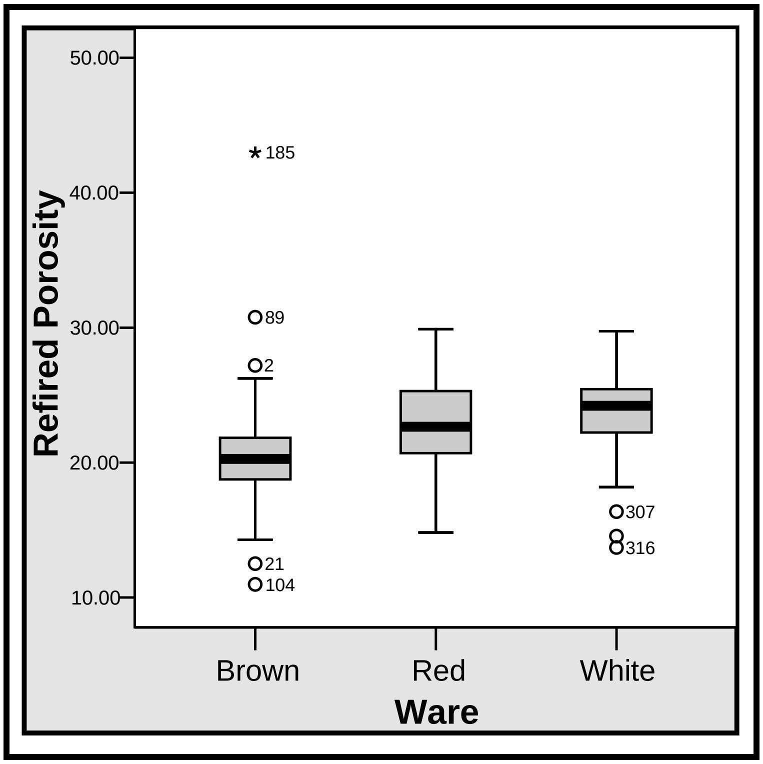


Figure 37. Mean Refired Porosity (%) for Brown Smudged, Red, and White Painted Bowls; Cox Ranch Pueblo.

A one-way ANOVA confirms that the mean difference in refired apparent porosity between the red and white painted sherd groups is greater than that between them and the brown smudged sherd group (*F=33.6*, *df=342*, *p=.000*). The raw materials used for brown and red ware are more similar than those used for white painted ware.

Table 12. Summary of Descriptive Statistics for All Red and Brown Ware Analyses
(U.AP = unrefired apparent porosity, R. AP = refired apparent porosity)

	U. AP	R. AP	Diameter (cm) from Rim Arc	Rim Thickness (mm) from Rim Arc	Whole Vessel Diameter (cm)	Whole Vessel Height (cm)	Whole Vessel Volume 1 (cm^3)	Whole Vessel Volume 2 (cm^3)	Whole Vessel Rim Thickness (mm)
Brown N	186	186	300	162	122	122	122	122	120
Brown Min	8.5	10.9	10	3	8	4	92	110.4	3
Brown Max	25.9	42.9	48	7.4	38	20	15121.5	14365.4	8
Brown Mean	17.7	20.3	22.1	4.6	19.4	10.5	2328.8	2418.58	5.5
Brown Standard Deviation	2.4	3.12	6.6	0.9	5.6	3.3	2149.5	2164.3	0.9
Red N	102	102	120	74	90	90	90	90	90
Red Min	14.4	14.8	12	3.5	10	5	261.7	261.7	4
Red Max	34.7	29.8	48	6.8	32	25	8117.8	8117	8
Red Mean	22.4	22.7	22.7	5.0	22	12.2	3117.3	3261.8	5.6
Red Standard Deviation	3.5	3.3	6.5	0.7	5.1	3.3	1875.3	1953.8	0.8
White N	57	57	137	61	16	16	16	16	15
White Min	12.9	13.7	6	2.8	12	5	376.9	454.3	3.2
White Max	28.5	29.7	46	7.1	28	14	5747	5747	5.8
White Mean	21.7	23.6	20	4	20.2	10.5	2487	2543.5	4.5
White Standard Deviation	3.6	3	6.9	0.8	4.9	3.2	1621.6	1635.2	0.7

Protein Residue Analysis

The results of protein residue analyses (Laboratory of Archaeological Sciences at California State University, Bakersfield) on four ceramic sherds from the Cox Ranch and Cerro Pomo great houses were negative. Residues were removed from these sherds with an immunological method known as CIEP (see Chapter 5) and tested against 26 animal and plant antisera. No positive reactions with these proteins were registered.

The absence of identifiable proteins on the artifacts may be due to poor preservation of protein, insufficient protein, or that they were not used on any of the organisms included in the available antisera (Yohe 2007). With the relatively large number of antisera tested, its seems unlikely that these sherds were involved in the processing of an unrepresented food type (see Table 2, Appendix J). These analyses are notoriously "hit-or-miss," as proteins can be lost from sherds in the soil after burial. Factors which may affect protein preservation on sherds include clay chemistry (pH) and oxidation, as high temperatures destroy protein (Evershed and Tuross 1996; McCabe 1992; Norman Henrickson, CSUB, personal communication 2007).

In theory, the sherds from Cox Ranch and Cerro Pomo pueblos should be good candidates for protein residue analysis; the site provides relatively good preservation, samples were taken from sufficient depths in room contexts without evidence of oxidation, and the sherds were washed in water only—only the use of detergent should be detrimental to proteins. Unfortunately, this analysis does not get us any closer to evaluating the functional similarities between brown smudged and red painted ware. Future studies may be more informative with sherds that have not been washed and were carefully collected and handled in situ specifically with these analyses in mind.

Gas Chromatography/Mass Spectrometry

Six ceramic sherds were submitted to Dr. Mary Malainey of Brandon University, Manitoba for analysis of fatty acids or lipids by Gas Chromatography/Mass Spectrometry (GC/MS) (Appendix K). These samples consisted of three brown smudged ware sherds and three red painted sherds from Cox Ranch and Cerro Pomo in the hopes that inferences about vessel function could be made and compared between the two wares. All six samples contained fatty acid residues that could be generally related to possible animal and plant foods, though

Malainey (2007:9) warns that the identifications given do not necessarily mean that those particular foods were actually prepared in the pots because different foods of similar fatty acid composition and lipid content will produce similar residues. Therefore, we can only definitively say that the origin of the residues is similar in composition to general categories of foods as previously recorded.

An in-depth description of the GC/MS methods used in this analysis is given by Malainey (2007, Appendix K), so I will only briefly describe them here. Each sherd was sub-sampled and crushed, at which point the absorbed lipid residues were extracted with organic solvents. Next, the relative percentage composition of all fatty acids in the sample was determined and then compared to 10 known fatty acids using a gas chromatagraph (Malainey 2007:9-10). Malainey's identification criteria was based on her own extensive work characterizing more than 130 modern uncooked Native food plants and animals from Western Canada and experimental data on the effects of cooking and degradation of fatty acids over time (Malainey 1997; Malainey et al. 1999).

The brown ware samples (designated with lab numbers 7CX 1 through 7CX 3) all exhibited moderate to high levels of fatty acid C18:0 (15 to 26 percent), which likely results from the preparation of large herbivore products such as bison, deer, moose, fat elk meat or other bovines or cervids (Malainey 2007:10 and Table 4). In addition, these three sherds exhibit low levels of fatty acid C20:0 (2-5 percent), which indicates the presence of plant material. The most interesting observation of the brown wares is the exceedingly high levels of fatty acid C16:0 (56-62 percent) which appears in all archaeological food residues and has been observed in high levels in pottery from the American Southwest. Malainey (2007:11-12) posits that the high levels of C16:0 may be due to the presence of a sealant applied to the pots, and that the differences in the fatty acid compositions of the residues likely relate to vessel function. It is tempting to infer that this sealant is related to the smudging present on these vessels, however, C16:0 is present in varying levels (28-32 percent) in all of the red ware samples as well, the highest being sample ZCX 5 (51%). Therefore, the fatty acid may be a component of the slip that is common to both wares.

The red ware samples (7CX 4 through 7CX 6) exhibit levels of fatty acid C18:1 between 17 and 20 percent which can be related to a wide range of animal and plant foods. However, given the elevated levels of medium chain fatty acids in samples 7CX 5 and 7CX 6, they are likely of plant origin. Red ware sample 7CX 3 stands out for its over 50 percent level of C18:1, a fatty acid present in very high fat content seeds or nuts such as pinon or in fresh rendered fat from mammals (Malainey 2007:11). Low levels of plant material are also present in the red ware samples.

Based on these analyses, it appears that both brown and red wares contain generally similar food residues and therefore likely had similar functions, though there are subtle differences. Red wares, on average, exhibit residues of higher fat content than those of brown ware; and brown ware exhibits higher levels of a residue which may be related to the application of a sealant. In general, they all exhibit residues related to the preparation of a combination of medium or moderate-high fat content foods of plant and animal origin. Known plant food sources with this fat content include prickly pear, corn, cholla, mesquite beans, nuts and seeds; whereas animal food sources include fish, winter-depleted elk, medium-sized mammals and rendered animal fat (Malainey 2007:Table 5).

The following chapter provides a summary discussion of the findings from vessel size and use as well as their implications for Pueblo and Mogollon identity and social organization.

CHAPTER 9
DELVING INTO THE PAST LIVES OF POTTERY AND TAKING STOCK: DISCUSSION & IMPLICATIONS

"We know too much, and we can't simply retreat to our trowels, our trenches, our lab coats, and our narrow empiricism or naïve realism" (Watson 1992:134).

The preceding data analyses were conducted to answer the following research questions in turn: Are Mogollon Brown Smudged Ware and White Mountain Red Ware functionally similar in terms of size and physical attributes? Were each of these ceramic wares used similarly as serving bowls? Are there differences in the raw material (clays) used to produce each of the wares?

The analyses provided some insight into the similarities and differences between brown smudged and red painted bowls, though they may be interpreted in several ways. First, size analyses are contradictory depending on the scale of investigation: estimated diameters of sherds at the site-specific level are statistically similar for red painted and brown smudged bowls but at a larger regional scale, the mean sizes of whole vessels are different. Based on rim arc, red painted and brown smudged sherds are more similar to each other in size than to smaller white ware bowls. In contrast, white painted and brown whole vessel sizes appear to be more similar to one another than to red painted. This observation may be spurious however, since the whole white bowl sample is very small (n=16). For both rim arc and whole vessel data, red painted wares are consistently slightly larger in size, but brown smudged ware have a wider range in sizes. As for physical attributes of whole vessels, height and calculated volume both exhibit statistically significant differences for brown smudged and red painted bowls. However, an interesting observation is that measures of rim thickness are similar between the two wares. If we can use rim thickness as a property of technological style, this could possibly indicate that potters with a similar manufacturing method resulting from similar historical backgrounds, or it could indicate the functional requirements of the vessels and the clay used.

In regards to whether or not brown and red bowls were used in similar contexts as serving bowls, the unrefired apparent porosity data shows that the two wares were used differently. The red painted bowls have a higher unrefired porosity than brown smudged, and white and red painted bowls are more similar to each other than to the brown smudged. However, when we compare the unrefired apparent porosity of brown jars and bowls, they are significantly different, relegating higher porosity jars to the role of cooking pot and less porous bowls to the role of serving vessel.

Lastly, raw material use for red and brown wares was assessed using measures of refired apparent porosity. These data indicate that the clays used to make red and brown bowls are inherently different, and that red and brown ware clays are more related to each other than to those of white wares.

In sum, the hypothesis that White Mountain Red Ware and Mogollon Brown Smudged Ware will exhibit a similar range of sizes is supported at the small scale of individual sites, likely indicating similar function for both wares. It is important to remember, however, that all of my size data are derived from great house contexts; therefore these patterns could be related to vessel function specific to great houses.

The domination of ceramic assemblages by brown ware over red ware is very visible at a regional scale. Brown ware clearly increases from north to south as red ware decreases. Most interesting is that sites roughly within the Southern Cibola region, near Cox Ranch and Cerro Pomo, exhibit fluctuating proportions of red and brown ware. This likely indicates that ethnic co-residence of Mogollon and Pueblo people was common and variably composed in the region.

The Pueblo II period may be the beginning of this pattern that intensifies later in time throughout the southern Southwest.

Additional variability is evidenced in the whole vessel data. The sizes of whole vessels from a wide range of sites in the area are not statistically similar. My second measure of vessel function, unrefired apparent porosity, is ambiguous. The clay's porosity indicates that brown and red ware bowls may have been used differently. However, a more specific measure of vessel function, the volume of open pores, indicates that both brown and red bowls were the same in regards to function. Well-insulated vessels are ideal for serving foods.

Gas Chromatography/Mass Spectrometry analysis of fatty acids present on brown smudged and red ware sherds, presumably a direct measure of vessel function, indicates that both vessel types were used for the same general types of plant and animal foods. However, the brown ware sherds exhibit more lipids representing large herbivore products, whereas some of the red ware exhibits more lipids associated with high fat content plants. Interestingly, both brown and red sherds (though markedly higher in brown ware) exhibit high levels of a fatty acid which may represent a sealant applied to the pots or may be a component of the slip. This could indicate that differences between the wares relate to vessel function. More likely, smudging on brown ware could have served the dual function of improving vessel use properties and as a highly decorative aspect of serving bowls.

Regardless of slight variation in the quantitative results, much circumstantial evidence points to the importance of Mogollon smudged brown ware relative to White Mountain Red Ware in the Southern Cibola region. Most importantly, both Mogollon/Pueblo interaction and an increasing prevalence of smudged brown ware occurs post-A.D. 900 and increases notably through time. These dates coincide with the decline in late Pueblo II of Chaco as a regional center. If migration and reorganization was a characteristic of this time period, then it seems likely that residents in transitional Mogollon/Pueblo areas with dominant Mogollon material culture (i.e., Cox Ranch and Cerro Pomo) found it increasingly important to maintain and reinforce their cultural identity.

Why would potters preference brown smudged pottery over red painted? One possibility may be exchange networks. Ceramic differences could reflect geographic differences in clay sources between the Mogollon highlands and the Colorado Plateau, and may be explained by exchange and its role as an economic buffer (Elyea et al. 1994; Tainter 1980). In the exchange model, drops in frequencies of certain types would indicate the boundaries of trade networks. Crown (1981:270) asserts that the lower numbers of brown wares at sites in the St. Johns, Arizona area were brought in through trade from more Mogollon-dominated sites to the south. She raises the possibility that brown wares, particularly smudged varieties, were exchanged for decorated wares because they were not part of the local tradition of gray ware and were prized as the aesthetic equivalent to painted ceramics. However, local production of White Mountain Red ware has been extensively documented in the area. In the Cerro Pomo and Cox Ranch areas, both brown and buff-firing clays are locally available, therefore trade networks seem an unlikely explanation (Duff and Nauman 2007, Nauman 2007). Another possibility is that the high number of smudged vessels indicates some type of low-level specialization, which would then indicate that smudged bowls had a particular function. Again, research into inter-site provenience of brown smudged has shown that it seems to be present equally throughout all site contexts at Cerro Pomo and Cox Ranch.

Regardless, it is increasingly apparent that at Cerro Pomo, Cox Ranch, and likely other sites in the immediate area, there was co-residence of both Pueblo and Mogollon people.

Whether both social groups founded the communities together, or the Pueblos arrived later is unknown. The lack of Pueblo I settlements in the area suggests that Mogollon people also migrated to the area likely from the Mogollon highlands to the south. However, the Mogollon tradition is dominant, an intuitive result if Pueblo people were migrating south into Mogollon-transitional areas.

In sum, the data suggest that potters may have been choosing to use brown smudged bowls instead of red painted ones, their functional equivalent. This choice would have been predicated on the likely fact that they knew how to make both wares and had access to the necessary raw material. The red painted tradition, although not widespread at this time, was more visible archaeologically just north of the project area. Mogollon potters were clearly opting not to replace their familiar brown ware with red painted ware. In an environment characterized by immigration and integration of new people into a community, it is not hard to imagine that Mogollon people wanted to reinforce a familiar historical tradition. Increasing evidence suggests that the residents of sites like Cox Ranch and Cerro Pomo may have truly shared a "frontier experience" (Herr 2001) less centered on Chaco and more on the creation of ethnically "blended" communities.

Data Limitations and Additional Research Possibilities

The variation in apparent porosity results could indicate that brown smudged and red painted bowls had fundamentally different uses. This could lend support to the arguments that smudging was a technique used specifically to heighten the use properties of bowls rather than as pure decoration as I argue. On the other hand, it may highlight the need to question the effectiveness of apparent porosity measures in general (Rice 1987:353). High-fired commercial ceramics are most often tested with material science methods such as apparent porosity and then used to make inferences about prehistoric technology, but low-fired prehistoric pottery exhibits many inherent differences. The property that is actually being measured is residual or estimated porosity because the porosity of archaeological ceramics may have been reduced by post-depositional abrasion which can clog pores. Furthermore, prehistoric pottery exhibits extensive surface variability such as fissures and holes which is amplified when slip and paint are applied to a clay body, and these things can affect clay permeability (Grimshaw 1971; Rice 1987). This point could be particularly applicable with smudged bowls; the application of thick slip to create the smudging effect could be masking the clay properties.

As I have mentioned (see Chapter 5), estimating vessel size from rim sherds can be less accurate than measurements from whole vessels. Since the statistical analyses indicate that the sizes of brown and red ware bowls were different, this may be the more accurate result. However, the drawback with museum collections is the issue of provenience. Most of the vessels that I studied were from private collections, and their site context is unknown. I controlled for temporal variation in the size data by only including vessels from the Pueblo II period, but the wide range of possible proveniences and site functions could skew any conclusions about similarities and differences between the wares.

I have demonstrated through the measure of refired apparent porosity that smudged brown ware and red painted bowls were manufactured from inherently different clays. Furthermore, previous oxidation studies (Duff and Nauman n.d.; Nauman 2007; McDougall 2007) from Cox Ranch and Cerro Pomo indicate that different clays were selected for different types of ceramic wares, and that these clays were locally available. Additional oxidation studies specifically involving brown smudged and red painted ware need to be conducted to assess the clay differences. Lastly, the low-tech methods used here to assess available sources constitute preliminary evidence, but it is not possible to determine whether or not the sampled clay sources near Cox Ranch and Cerro Pomo were actually used for pottery manufacture without more sophisticated compositional analyses of clays through one of many techniques such as NAA, ICP-MS, or X-ray fluorescence (Harbottle 1982). NAA analyses are presently being conducted by Andrew Duff.

We know very little about the Mogollon smudging technique, therefore research possibilities abound. Experimental pottery manufacture is one area for further study that I think could result in valuable information regarding whether smudging is a stylistic or functional technique. Experimental studies by Schiffer et al. (1994) and Skibo (1997) have shown that smudging increased resistance to cracking and abrasion. However, smudging was but one of many surface treatments tested in these studies. A study dedicated specifically to testing the properties of smudging under various conditions could be very fruitful.

Implications

"It is good for an archaeologist to be forced to take stock, to survey his field, to attempt to show what bearing his delving into the past may have upon our judgment of present day life; and what service, if any, he renders the community beyond filling the cases of museums and supplying material for the rotogravure sections of the Sunday papers" (Kidder 1940:528).

What is the larger relevance of discovering that Mogollon people used brown pots in larger numbers than red pots? In a nutshell, it illustrates the importance of individual decision-making in society and the fact that we can see traces of these decisions, albeit far-removed, in the archaeological record in the form of style. Deitler and Herbich (1998) call for a definition of style centered on the distinction between things and techniques in material culture; the former being the physical objects or artifacts and the latter being the processes or techniques resulting from the human action that created them. "This approach requires that we understand craftspeople as social actors (rather than simply as products/bearers of culture or as acultural adaptive engineers) and that we understand the production and use of objects as social activity" (Dietler and Herbich 1998:246). People actively negotiate social rules, creating and transforming social structure (Hodder 1985:2,7). Culture is not an abstract system, but rather a logical system created by individuals trying to make sense of their world. Agency and practice theory rose from the need the understand the relationship between individual action and the social system, the origins of this system, and how it is produced and reproduced with the cooperation of actors (Ortner 1984:157).

As I have shown in this study, decision-making is specifically evident in ceramic style. The stylistic communication that is evident in Mogollon ceramics could have taken the form of isochrestism (Sackett 1990) or emblemic style (Wiessner 1983). Cox Ranch and Cerro Pomo potters had numerous choices in the pottery production process that could result in equally viable results (Wiessner 1983:257). The best illustrations of this are the overwhelming use of brown smudged bowls rather than brown plain bowls, and the selection of brown-firing clays even though three distinct types of clays are available locally. Both light and dark-firing clays are available locally that will produce white, brown, gray, or red ceramic wares (with proper oxidizing or reducing firing). However, there is a predominance of only one of these wares – brown – reflecting a specific *choice* made by potters in the manufacturing process.

Mogollon ethnicity is embedded in the fabric of these pots, in the way they are built. When compared to Puebloan gray utilitarian cooking pots at the same site, brown pots served the same function, but they were visually and technologically different, and were manufactured using different clays (see case study, Chapter 5). Sackett (1990:33) echoes this point regarding the importance of embedded style versus more visible decoration when he states that "these isochrestic alternatives, some or even possibly all of which, can be just as ethnically – and hence stylistically – significant as the decoration that may be applied to its surface."

We can take this point a step further and use Wiessner's (1983) concept of emblemic style to explain the ubiquity of smudged brown ware at Cox Ranch and Cerro Pomo. Potters at these sites can make an equally viable plain brown bowl that serves its function for serving food, but they chose overwhelmingly to smudge them (a delicate and time-consuming firing process). It does not seem plausible that smudging was a technique (comparable to painted designs) that could be learned and spread somewhat easily because the firing process would require more direct teaching to learn. The manufacture process would be characterized by engagement in close or regular relationships.

The smudging technique results in a surface with a dark black luster that I argue is a visible signal of Mogollon identity. Style need not be complex. Smudging as a stylistic technique does not involve the interaction of painted symbols to encode information, but carries meaning nonetheless as an inherent signal of identity and an underlying residue of a "way of doing." The smudging technique is highly visible formal variation in material culture that carries a clear message of conscious affiliation with the Mogollon tradition.

More importantly, the smudging technique overshadows the use of painted red ware bowls, the more traditional medium to the north and west of the study area. Perhaps this remnant red ware tradition is associated with migrant Pueblo groups moving into Mogollon-dominated sites. Emblemic style is apt for this example: it is formal variation in material culture that has a distinct referent and transmits a clear message to a defined target population about conscious affiliation or identity (Wiessner 1983:257). Emblemic style, as uniform and clear, would be expected to change gradually over time as an "all or nothing occurrence" which would be used to deal with social boundaries (Conkey 1989).

Smudging would be a highly visible aspect of serving bowl interiors, but who was the audience? A smudged surface is likely most visible in close proximity, whereas the brown undecorated exterior of a bowl is visible at a distance. Similarly, red painted designs on a bowl interior are visible up close while the plain red exterior can be seen from further away. I think these properties of the serving vessels at Cox Ranch and Cerro Pomo are important because they were signals of ethnic identity at a small scale. Mogollon and Pueblo people were living together in close proximity and likely integrated for ritual or other community events. The smudged and red painted interiors of bowls would be visible symbols of ethnicity at a domestic scale—it would be important to those consuming the food—whether they are the members of one household or participants in a community-wide event. In contrast, the distinction between brown and red was visible between households with differing social histories.

I do not mean to imply that based on archaeological data we can know what potters were thinking in regards to choices they make about pottery manufacture. Instead, I argue that we can know something about the cultural background of potters because aspects of their distinct technologies are evident in ceramics. These technologies are rooted in specific histories that we can term ethnicity or identity. I recognize that ethnicity can be a loaded term in general, especially when applied to archaeological contexts, but I use it here as an extension of enculturation—the result of histories that are specific to one social group. The differences that we see between Mogollon and Pueblo pottery are the result of the different ways that Mogollon and Pueblo children were taught. The integration of emblemic style and isochrestic variation that I have advocated here could be likened to the concept of *habitus* (Bourdieu 1977; Dietler and Herbich 1998). Style is deliberate and is embedded in cultural values. To some degree, Mogollon potters make brown smudged pottery because it is what they know, the *habitus* becomes somewhat rote with experience. However, it is significant to maintain a distinct ceramic tradition (brown ware) when faced with the option to make a different type of pottery (red ware) that for all intents and purposes is functionally similar.

There are examples from ethnography and ethnoarchaeology that lend support to the idea that differences in material culture relate to identifiable social boundaries between groups of people. Gosselain (2000:193) compares pottery techniques across multiple regions in Africa and finds that the act of fashioning a pottery vessel is “most rooted in aspects of social identity such as kinship, language, and gender.” These pottery forming techniques map onto widespread language family distributions or gross ethnic groupings. Potters within a specific community share the same techniques for clay selection and processing, forming, and firing (Gosselain 2000). Similar examples from West Africa (MacEachern 1998) and the Philippines (Stark et al. 2000) show that individual and group identity correlate with material culture and can be related to the need for social cohesion during times of economic stress (Hodder 1979). Bowser (2000) finds that the design differences in pots made by women in Ecuador signal political alliances rather than ethnicity—another aspect of social identity. Women make choices to align their pottery decoration with one of two political factions, or even choose to distinguish themselves completely from the social system with distinct designs. The learning of pottery techniques is fluid in this example. “Women report adopting new techniques of manufacture and decoration after they have moved to new communities as adults and established relationships with different women” (Bowser 2000:227). These examples do not show that there are clear-cut relationships between ceramics and ethnicity, the variability in the archaeological record in particular highlights that correlates can be complex. These examples do however, show that people identify with familiar technology and use material culture to negotiate their social identity.

The Big Picture: Identity During and After Chaco

The subtle distinctions in the visibility of pottery decoration that I have described for Pueblo II sites such as Cox Ranch and Cerro Pomo differ markedly from later sites (Pueblo III and Pueblo IV, A.D. 1175-1400) in which highly decorated exteriors of large bowls coincide with a change in architecture to open plazas that incorporated large groups of people in ritual and feasting (Mills 2007). Cox Ranch, with 300+ rooms is comparable to some Pueblo III and IV sites, some of which also had integrated populations of both Mogollon and Pueblo people (Reid et al. 1996). This difference is significant because it marks a change from small to large-scale differentiation between groups with different cultural backgrounds.

The marked differences in site architecture and social organization that we see during the transition from the Pueblo II to Pueblo III periods frames my next point about the larger relevance of Chacoan ideology to Cox Ranch and Cerro Pomo and the southern Cibola region as a whole. I have speculated that Cox Ranch and Cerro Pomo were not directly involved in the Chaco regional system based on variability in site architecture and few material culture ties, however, the overarching similarities between outlying great house sites and those in Chaco Canyon implies far-reaching knowledge of the Chacoan way of life. The spread of Chacoan ideology may have become an increasingly important way to integrate Mogollon and Pueblo people, even after the decline of Chaco Canyon proper (Duff and Schachner 2007).

There is a large population expansion during Pueblo II from the northern southwest into southern Mogollon areas. This becomes even more evident during the post-Chaco era, when sites became more aggregated and highly organized with individual households much less visible

(Duff and Lekson 2006:324). This pattern persists into the historic era for pueblos in the region. In fact, in the Zuni-Acoma area—a subset of the southern Cibola region—many "Chacoan" great house sites actually had primary occupations that date after the decline of Chaco Canyon itself (Duff and Lekson 2006:322). These later sites are often centered on a plaza and have large circular unroofed great kivas—architecture which could foster the integration of ethnically diverse groups of people under a familiar ideology.

After Pueblo II, the Zuni-Acoma and Southern Cibola regions exhibit settlement patterns more Pueblo-influenced, but still have Mogollon-dominated material culture. Haury (1985) and others have posited that there is a "takeover" of Pueblo culture in these areas after A.D. 1000, but we do not see this at Cox Ranch and Cerro Pomo. The ceramic technology indicates that the Mogollon and Pueblos were still two distinct groups, with the Mogollon reinforcing their identity through pottery technique.

Sites on the southern frontier of Chaco influence that were occupied on the cusp of the changes occurring in late Pueblo II to Pueblo III such as Cox Ranch and Cerro Pomo may represent the "last holdout" in the sense that they were able to maintain ethnic diversity at the household level. Increased migration through time of Pueblo people into Mogollon-dominated areas may have created tension and a need for peaceful integration. Distinct ceramic traditions and architectural variation may not be as visible as communities become more ethnically blended. Whether the adoption of Chacoan ideology helped to foster cooperation rather than competition between people with Pueblo or Mogollon backgrounds remains to be seen; however few examples of violence are found at large aggregated sites such as Grasshopper Pueblo after A.D. 1200. Using ceramic assemblages with greater temporal control on red, gray, and brown wares over time it may be possible to determine whether people with Pueblo histories and embedded ceramic traditions were making Mogollon brown ware as well, signaling integration and cooperation.

As Chaco's status as a central place declined, Chacoan attributes remained visible across the Southern Cibola landscape at widespread distances from the canyon itself. Post-Chaco there may have been a revival of Chacoan ideology to bring people with diverse backgrounds together who shared these familiar ideas. This seems especially likely if the "power" that drew people to Chaco was based in ritual rather than on economic or political foundations. If Chaco Canyon served as a place of religious pilgrimage, then residents of sites at a great distance from the canyon would have knowledge of what it meant to be "Chacoan." The great house itself would serve as the center of a community based on its ideational or devotional significance (Renfrew 2001), and the presence of this familiar architecture along with a religious system that thrived on community ritual interaction could integrate people from diverse backgrounds.

The significance of research into Mogollon-Pueblo cultural differences is evidenced by the long time period for which distinct Mogollon material culture is visible in the archaeological record. Eventually, however, Mogollon traits appear to become absorbed into the characteristic Puebloan style of architecture and material culture. Modern pueblos such as Zuni may very well be the result of the combination of Mogollon and Pueblo histories.

Pottery is an excellent medium for communicating social, political, and economic messages. The need to display these kinds of messages increases as societies become more complex, and as the need grows for individuals to distinguish themselves from others. Cox Ranch and Cerro Pomo, with variation in site architecture based on the theme that is reminiscent of the Chaco site plan and demonstrated ethnic co-residence may well represent transitional sites on the "frontier" whose residents were actively negotiating identity and social change.

The moving finger writes; and, having writ,
moves on: nor all thy piety nor wit
Shall lure it back to cancel half a line,
Nor all thy tears wash out a word of it

-The Rubaiyat of Omar Khayyam

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APPENDIX A: Raw Data and SAS Output for Correspondence Analysis, Cox Ranch and Cerro Pomo

(CR=Cox Ranch, CP=Cerro Pomo, GH=Great House, GK=Great Kiva, M=Midden, RB=Roomblock)

Site	Area	Ar#	Unit	Reserve	PuercoR	KIA_RM	ES_GA_PU	WIN	AllBrown	AllGray
CR	GH	0	1	15	5	0	27	4	67	16
CR	GH	0	2	8	3	0	19	1	61	3
CR	GH	0	3	77	5	2	57	0	155	22
CR	GH	0	4	196	40	3	284	22	920	228
CR	GH	0	5	153	15	5	174	12	494	196
CR	GH	0	6	242	12	2	170	56	726	238
CR	GH	0	7	93	2	0	39	28	258	93
CR	GH	0	8	100	7	3	81	32	353	99
CR	GH	0	9	107	23	7	140	34	461	161
CR	GH	0	10	63	2	1	59	11	280	78
CR	GH	0	11	41	7	0	12	3	100	27
CR	GH	0	12	146	26	4	88	8	1104	446
CR	GH	0	13	193	5	0	54	14	425	53
CR	GH	0	14	14	1	3	5	2	50	10
CR	GH	0	15	242	29	12	142	29	784	275
CR	GH	0	16	270	18	7	244	37	945	228
CR	GH	0	17	101	39	1	69	29	380	240
CR	GK	0	1	60	6	1	44	28	194	16
CR	M	1	2	56	6	4	81	11	311	35
CR	M	1	3	18	9	0	45	3	104	15
CR	M	1	4	12	0	0	18	1	100	33
CR	M	1	5	8	3	0	15	0	101	14
CR	M	3	1	4	1	5	16	2	80	4
CR	M	3	2	9	2	1	29	0	79	5
CR	M	3	3	15	2	1	44	7	90	17
CR	M	3	4	38	7	3	68	13	197	40
CR	M	3	5	23	3	0	26	7	168	16
CR	M	6	1	32	2	1	17	15	136	27
CR	M	6	2	30	1	1	31	22	163	35
CR	M	6	3	45	6	1	29	23	132	25
CR	M	6	4	17	2	2	28	11	98	25
CR	M	6	5	36	5	3	40	25	150	36
CR	M	7	1	3	1	0	3	1	41	12
CR	M	7	2	1	0	1	1	2	34	6
CR	M	7	3	67	11	0	50	19	286	58
CR	M	7	4	10	0	1	1	0	26	4
CR	M	8	2	28	0	0	1	1	35	3
CR	M	8	3	11	3	0	13	8	111	37
CR	M	8	4	6	0	0	0	0	32	1
CR	M	8	5	1	0	0	4	4	50	13
CR	M	10	1	3	0	0	11	1	35	7
CR	M	10	2	9	5	0	10	5	28	13
CR	M	10	3	4	0	0	7	2	45	9
CR	M	10	4	5	2	0	37	8	112	11
CR	M	10	5	3	0	3	19	2	52	5
CR	M	10	6	9	3	0	24	3	53	14
CR	M	11	1	33	7	0	49	14	148	53
CR	M	11	2	28	5	0	15	4	69	37
CR	M	11	3	25	4	0	14	5	65	19
CR	M	11	4	26	0	0	19	7	81	41
CR	M	11	5	12	4	0	10	3	46	15
CR	M	11	6	26	4	1	11	1	83	22
CR	M	12	1	72	13	4	175	11	479	126
CR	M	12	3	40	4	5	92	4	270	64
CR	M	12	4	57	13	5	153	7	335	88
CR	M	12	5	34	3	5	118	0	266	84
CR	M	12	6	85	21	5	250	11	564	135
CR	M	13	1	8	4	0	23	5	115	35
CR	M	13	3	13	1	0	21	5	85	21
CR	M	13	4	23	5	0	24	8	96	19
CR	M	13	5	7	0	0	3	3	51	8

Site	Area	Ar#	Unit	Reserve	PuercoR	KIA_RM	ES_GA_PU	WIN	AllBrown	AllGray
CR	M	13	6	10	0	4	8	0	100	41
CR	M	15	1	119	18	8	194	20	433	118
CR	M	15	2	38	9	1	62	17	218	42
CR	M	15	3	6	0	2	22	2	49	21
CR	M	15	4	33	7	0	53	7	120	26
CR	M	15	5	16	8	5	48	2	63	26
CR	RB	2	1	0	0	0	0	0	1304	1
CR	RB	2	2	0	0	0	1	0	1	0
CR	RB	2	3	1	0	1	3	0	25	3
CR	RB	2	4	31	4	0	42	8	177	21
CR	RB	2	5	11	3	1	16	1	84	17
CR	RB	2	6	76	0	0	17	2	98	18
CR	RB	2	7	37	4	0	100	12	101	20
CR	RB	2	8	227	0	0	34	8	775	9
CR	RB	2	9	0	0	0	0	1	0	2
CR	RB	2	10	0	0	0	0	0	0	7
CR	RB	7	1	108	25	0	62	48	320	182
CR	RB	15	1	0	0	1	167	1	53	1
CR	RB	15	2	0	0	1	0	9	218	0
CR	RB	15	3	7	0	0	2	3	16	2
CR	RB	16	1	11	3	0	11	0	137	82
CP	GH	0	1	24	1	2	36	4	118	2
CP	GH	0	2	54	0	0	60	0	145	27
CP	GH	0	3	22	0	0	20	2	113	10
CP	GH	0	4	13	0	0	44	3	212	17
CP	GH	0	5	17	0	0	7	0	93	6
CP	GH	0	6	13	2	0	35	3	137	26
CP	GH	0	8	6	0	0	14	1	20	5
CP	GH	0	9	40	1	0	32	4	122	15
CP	GH	0	10	37	1	0	5	30	148	15
CP	GH	0	11	2	0	0	6	0	84	16
CP	GH	0	12	14	0	5	18	2	318	16
CP	GH	0	13	58	9	2	40	6	274	76
CP	GK	0	1	2	0	1	4	0	2	5
CP	M	1	1	28	3	1	27	5	302	17
CP	M	1	2	10	2	0	18	3	69	16
CP	M	1	3	31	5	1	33	10	284	33
CP	M	1	4	27	5	1	17	1	237	30
CP	M	1	5	3	0	1	13	2	109	8
CP	M	2	1	34	0	34	39	11	350	35
CP	M	2	2	37	4	5	40	7	560	42
CP	M	2	3	77	0	2	40	2	763	78
CP	M	2	4	25	1	1	19	5	311	38
CP	M	2	5	29	0	1	33	2	324	32
CP	M	2	6	13	1	8	11	1	169	14
CP	M	2	8	25	1	6	37	7	356	37
CP	M	2	9	22	0	7	9	0	282	22
CP	M	2	10	38	5	5	30	1	372	52

SAS Output
CA of Painted Ceramics From Cox Ranch and Cerro Pomo Pueblos by Test Unit
19:40 Sunday, October 21, 2007

LOG

```
1   title 'CA of Painted Ceramics From Cox Ranch and Cerro Pomo Pueblos by Test Unit';
2   proc corresp data=sasuser.ALLCA out=Results1 short;
3   var KIA_RM ES_GA_PU WIN PuercoR Reserve;
4   id ID1;
5   %plotit(data=results1, datatype=corresp, plotvars=Dim2 Dim1)
WARNING: 2 rows were excluded due to invalid or zero frequencies.
```

The CORRESP Procedure

Inertia and Chi-Square Decomposition

Singular Value	Principal Inertia	Chi-Square	Percent	Cumulative Percent	9 18 27 36 45
0.34949	0.12214	1399.41	42.77	42.77	************************
0.27590	0.07612	872.11	26.65	69.42	***************
0.24922	0.06211	711.59	21.75	91.17	************
0.15884	0.02523	289.07	8.83	100.00	*****
Total	0.28561	3272.18	100.00		

Degrees of Freedom = 444

Column Coordinates

	Dim1	Dim2
KIA/RM	-0.4234	1.9115
ES/GA/PU	-0.3628	-0.0807
WIN	0.3749	-0.0192
PuercoR	0.0189	-0.1959
Reserve	0.3459	0.0240

APPENDIX B: Chi-Square Raw Data and SAS Output, Cox Ranch and Cerro Pomo Jar/Bowl Ratios

Relationship Between Brown and Red Bowls/Jars and Site
19:58 Sunday, October 21, 2007

LOG

```
1   data chisquare1;
2   input   form $
3           site $
4           number;
5
6   datalines;

NOTE: The data set WORK.CHISQUARE1 has 8 observations and 3 variables.
16  title 'Relationship Between Brown and Red Bowls/Jars and Site';
18  proc freq data=chisquare1;
19  tables form*site / chisq norow cellchi2 expected measures;
20  weight number;
22  proc gchart data=chisquare1;
23  block site / freq=number
24  group=form;
25  hbar site / freq=number
26  group=form;
27  vbar site / freq=number
28  group=form
29
30  run;
```

The FREQ Procedure
Table of Form by Site

Form	Site: Frequency / Expected / Cell Chi-Square / Percent / Col Pct	BrownBow	BrownJar	RedBowl	RedJar	Total
CP	Frequency	2372	4251	296	14	6933
	Expected	2777.9	3531.5	575.7	47.886	
	Cell Chi-Square	59.311	146.59	135.89	23.979	
	Percent	9.15	16.40	1.14	0.05	26.75
	Col Pct	22.84	32.20	13.75	7.82	
CR	Frequency	8012	8950	1856	165	18983
	Expected	7606.1	9669.5	1576.3	131.11	
	Cell Chi-Square	21.662	53.536	49.63	8.7576	
	Percent	30.92	34.53	7.16	0.64	73.25
	Col Pct	77.16	67.80	86.25	92.18	
Total		10384	13201	2152	179	25916
		40.07	50.94	8.30	0.69	100.00

Statistics for Table of Form by Site

Statistic	DF	Value	Prob
Chi-Square	3	499.3517	<.0001
Likelihood Ratio Chi-Square	3	530.1108	<.0001

```
Mantel-Haenszel Chi-Square     1      1.6047    0.2052
Phi Coefficient                       0.1388
Contingency Coefficient               0.1375
Contingency Coefficient               0.1375

Gamma                                -0.0632    0.0122
Kendall's Tau-b                      -0.0294    0.0057
Stuart's Tau-c                       -0.0279    0.0054
Somers' D C|R                        -0.0356    0.0069
Somers' D R|C                        -0.0243    0.0047
Pearson Correlation                  -0.0079    0.0057
Spearman Correlation                 -0.0304    0.0059
Lambda Asymmetric C|R                 0.0000    0.0000
Lambda Asymmetric R|C                 0.0000    0.0000
Lambda Symmetric                      0.0000    0.0000
Uncertainty Coefficient C|R           0.0108    0.0009
Uncertainty Coefficient R|C           0.0176    0.0015
Uncertainty Coefficient Symmetric     0.0134    0.0011

Sample Size = 25916
```

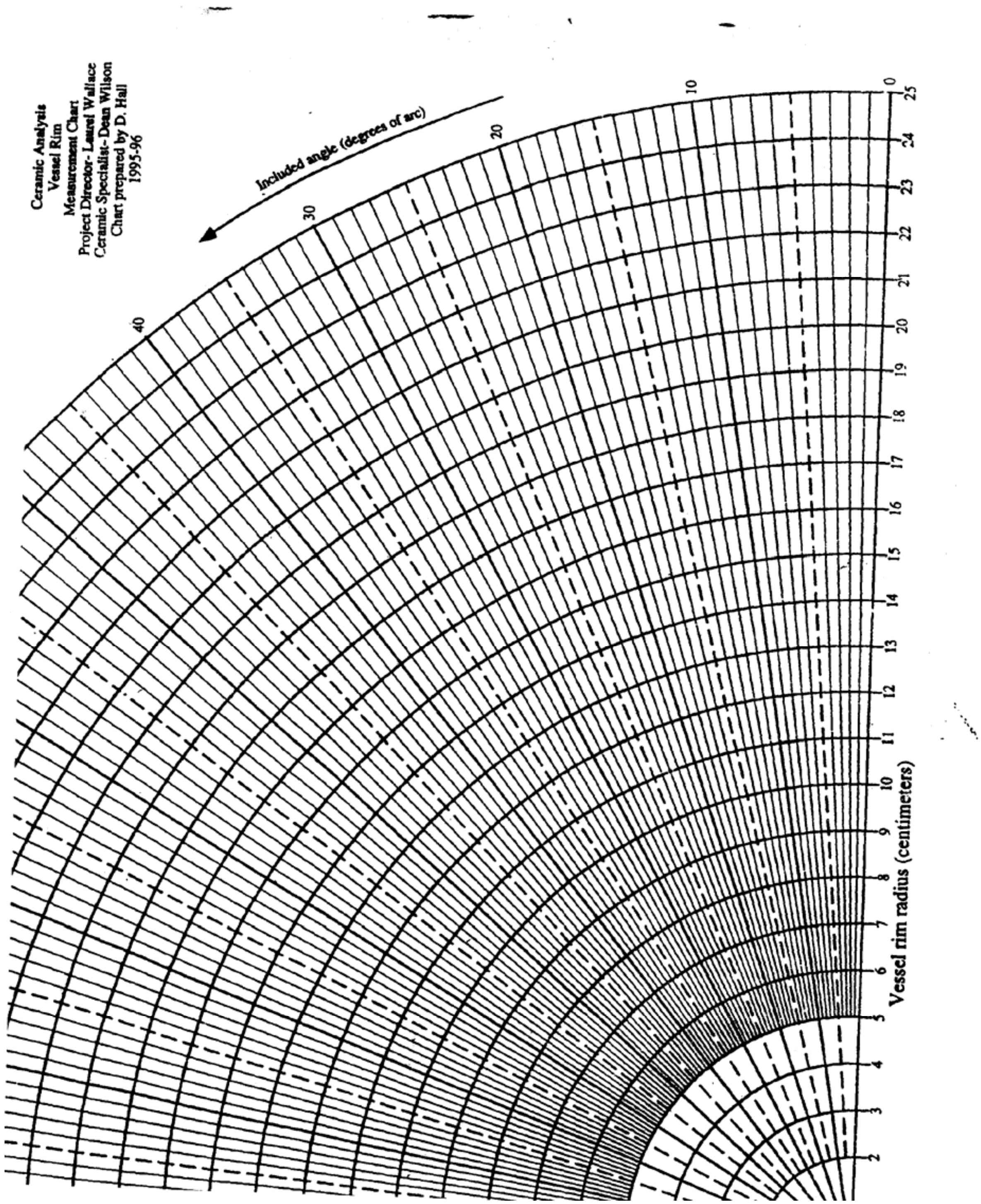
APPENDIX C: Ceramic Ware Distribution Data, Arizona and New Mexico

Map #	Site Group	Sites	Reference	Dates
1	Chaco Canyon, NM	29SJ629, 1360, 627, 633, 389	Toll and McKenna 1997:17-55; Tables 2.1 and 2.15	A.D 920-1200
2	Sander's Great House, AZ	16, 17, 24	Waterworth 1994:275-327	PII
3	Zuni, Y Unit Draw, NM	Village of the Great Kivas (631),115334, 26319, 115327, 26306, 115330, 48695, 115329, 26308, 115324, 115323, 115325, 49838, 115328, 115322, 115321, 115320, 115333	Eckert et al. 2000:550-585	1000-1200
4	Fort Wingate, NM	Multiple, aggregated	McEnany 1997:67-103	PII
5	El Malpais Nat. Mon., NM	Multiple, aggregated 1, 4, 5, 6, 7, 9, 11, 15, 26	Schachner and Kilby 2005:45-68; Marshall 1993:76-77	A.D. 950-1125
6	Silver Creek, Carter Ranch AZ	Hough's Great Kiva , Cothrun's Kiva, Carter Ranch Pueblo	Longacre 1964, Mills et al. 1999	A.D. 1080-1150
7	Danson – Nutrioso, Springerville - Little Colorado	102, 103, 154, 203, 357, 360-377, 382, 386, 387, 411; 51B, 51D, 62, 147, 151, 160, 163, 165, 166, 169, 463	Danson 1957:60,64	PII
8	TEP St. John's AZ	AZ Q:7:26 and Q:7:27	Crown 1981:233-319	PII - Early PIII
9	Mineral Creek, AZ	Mineral Creek site	Martin et al. 1961	1000-1200
10	Danson - North Plains & Mariana Mesa	31, 133, 135, 139, 474, 475; 141, 187, 191, 192, 473, 476, 477, 484, 488, 490, 494, 496, 498-500, 502, 503, 506, 507a, 509, 512, 514-518, 521, 523, 534, 538, 540, 542, 544, 547, 554, 560, 564, 568, 571, 573, 576, 577, 579, 581, 582, 584-587, 589-592, 596, 598-600, 602, 604-606, 608, 609, 618, 622-624, 629-631	Danson 1957:67, 71-73	PII
11	Armijo Canyon, NM	102813, 102815, 102820-21, 102826-27, 102829, 102831-33, 102837, 102839-40, 102842-44, 102846-48, 102852-53	Elyea, Hogan, and Wilson 1994: 49-69, Tables 6-9	PII – PIII
12	Cebolla Canyon, NM	20 sites, aggregated	Marshall 1991 Chapter 6:5-9, Tables 6.2-6.5	Late PI – Late PII
13	Danson - Rio Salado-Alamocita	111, 120, 121, 122	Danson 1957:79	PII
14	NZ Survey, NM	9, 10, 11, 13, 15, 26, 27, 32, 34, 35, 41, 43, 56, 59, 61, 64, 72, 79, 84, 85, 87, 91, 99, 101, 102, 104, 105, 109, 111, 115, 117, 118, 120, 121, 125, 127, 129, 130, 131, 133, 134, 135, 137, 139, 142, 152, 156, 158, 174	Mills 1990:89-117 Appendix III	PII – Early PIII
15	Fence Lake Mine Excavations, AZ, NM; Carrizo Wash Valley AZ; San Augustine, NM	LA 48642, 48644, 48649, and 48540 AZ Q:8:40, AZ Q:8:57, and AZ Q:8:61 3, 227, 228, 239, 248, 250, 254, 255, 260, 270, 273, 274, 275, 280, 313, 314, 318, 319, 321, 322, 328, 329, 331, 429, 453, 455, 456, 457, 460, 462, 467, 469, 470, 471, 473, 474, 478, 479, 482, 489, 495	Ford 1988 Chapter 5:1-55; Hagiopan et al. 2004:941-1077; Mills 1987:83-10, Appendix 1	A.D. 1050-1175
16	Mariana Mesa, NM	481, 494, 601, and 188	McGimsey 1980	A.D. 1075-1200

Map #	Site Group	Sites	Reference	Dates
17	Danson - Tularosa River, Apache Creek, Hardcastle Creek - Perry Lawson	26, 36, 84, 415, 417, 429; 86, 100, 247, 248, 249, 252, 252, 257, 259, 260, 262, 267, 279, 280, 281	Danson 1957:42,44	PII
18	Danson - Gallo Mt. - Jewett Ranger Station, Johnson Basin - Seven Troughs	293, 294, 299, 302, 310, 315, 317, 319, 330, 332, 333, 334, 336, 337, 339, 340, 342, 348, 349, 352, 353, 389, 390-392, 394, 398, 399, 402, 403; 79, 207-210, 214, 216, 218-221, 222a, 222b, 224, 228, 229, 231, 234, 235, 236, 238, 240, 241	Danson 1957:47,52	PII
19	Danson - Largo Canyon - Agua Fria	109, 176, 177, 179, 180, 181, 182, 183, 184, 193, 195, 199, 201, 202, 610	Danson 1957:55	PII
20	Danson - Blue River & Upper San Francisco River	7, 8, 12, 16, 19; 45, 66, 277, 418, 420, 448, 443, 444, 445, 446, 447, 448, 449, 450. 451, 453, 457, 460, 461, 467	Danson 1957:33,38	PII
21	Pine Lawn Valley, NM	Wet Leggett, South Leggett, Three Pines Pueblo, Oak Springs, and Sawmill Site	Martin, Rinaldo, and Antevs 1949, Martin and Rinaldo 1950, Bluhm 1957	PII
22	Reserve Caves, NM	Y Canyon, Cosper, Hinkle Park, O Block	Martin, Rinaldo, and Bluhm 1954	1100-1200
23	Tularosa, NM	Higgins Flat Pueblo, Apache Creek Pueblo, Valley View Pueblo, Jewett Gap	Martin et al. 1957	PII - PIII
24	Danson - Mimbres, Lower Gila, Lower Blue - San Francisco Rivers	1, 23, 24, 46	Danson 1957:29	PII

Map #	Total	Gray	Brown	Brn SM	Red	Red Painted	White	% Brown of B/R	% Red of B/R	% Red Painted	% Gray	% Brown of G/B	Brn SM %
1	227820	127729	1948	1924	2231	2153	95912	0.47	0.53	0.55	1.31	0.02	0.99
2	13392	8319	423	278	619	14	4031	0.41	0.59	2.12	1.87	0.09	0.66
3	1691	881	15	10	236	133	559	0.06	0.94	1.65	1.53	0.03	0.67
4	11089	8011	54	0	596	717	2428	0.08	0.92	0.83	3.23	0.02	0.00
5	17891	9725	1525	68	252	184	6389	0.86	0.14	1.00	1.23	0.19	0.04
6	53944	709	27891	3440	3418	2060	21926	0.89	0.11	0.62	0.01	0.56	0.12
7	790	30	574	88	52	37	134	0.92	0.08	0.42	0.04	0.81	0.15
8	9766	3491	1460	913	903	753	3912	0.62	0.38	0.54	0.65	0.27	0.63
9	6683	152	3680	437	146	127	2705	0.96	0.04	0.26	0.02	0.58	0.12
10	2371	516	567	85	193	183	1095	0.75	0.25	0.72	0.31	0.34	0.15
11	1700	400	393	41	28	22	879	0.93	0.07	0.44	0.31	0.31	0.10
12	2834	1438	34	16	180	111	1182	0.16	0.84	1.42	1.18	0.03	0.47
13	166	6	95	20	10	10	55	0.90	0.10	0.33	0.04	0.63	0.21
14	2390	804	291	129	101	236	1194	0.74	0.26	0.28	0.54	0.20	0.44
15	16202	7632	2363	949	979	569	5228	0.71	0.29	0.64	1.01	0.31	0.40
16	32299	1003	14901	1214	4535	4125	11860	0.77	0.23	0.85	0.04	0.56	0.08
17	537	0	458	80	28	7	51	0.94	0.06	0.32	0.00	0.90	0.17
18	1549	19	1178	225	90	60	262	0.93	0.07	0.32	0.01	0.82	0.19
19	612	60	348	51	21	12	183	0.94	0.06	0.33	0.11	0.66	0.15
20	873	4	843	53	7	8	19	0.99	0.01	0.11	0.00	0.98	0.06
21	28140	208	25940	4357	406	31	1586	0.98	0.02	0.09	0.01	0.94	0.17
22	9413	14	8409	1563	680	29	310	0.93	0.07	0.43	0.00	0.96	0.19
23	15518	1	14132	3459	382	135	1003	0.97	0.03	0.11	0.00	0.93	0.24
24	228	0	160	0	12	0	56	0.93	0.07	0.00	0.00	0.74	0.00

APPENDIX D: Example Rim Fitting Chart



APPENDIX E: Raw Rim Arc Data, Cox Ranch and Cerro Pomo

(Sp#=Spec#, S=Site, U=Unit, L=Level, L=Locus W=Ware, R=Radius, Dm=Diameter, C=Cox Ranch, P=Cerro Pomo)

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
3	2913	P	1	1	1	B	6	20	12
4	2913	P	1	1	1	B	13	50	26
5	2913	P	1	1	1	B	7	40	14
6	2948	P	1	2	1	B	14	30	28
7	2948	P	1	2	1	B	9	60	18
8	2948	P	1	2	1	B	6	40	12
9	2948	P	1	2	1	B	10	50	20
10	2948	P	1	2	1	B	12	60	24
11	2948	P	1	2	1	B	6	20	12
12	2948	P	1	2	1	B	6	30	12
13	2948	P	1	2	1	B	12	80	24
650	2969	P	1	3	1	B	11	30	22
14	2896	P	2	1	0	B	10	70	20
15	2896	P	2	1	0	B	7	40	14
16	2905	P	2	2	0	B	8	30	16
17	2908	P	2	3	0	B	13	80	26
18	3079	P	3	6	3	B	9	30	18
646	3105	P	3	6	5	B	14	50	28
19	2939	P	4	0	1	B	5	50	10
20	2939	P	4	0	1	B	7	30	14
21	2940	P	4	1	1	B	6	50	12
22	2940	P	4	1	1	B	9	30	18
23	2940	P	4	1	1	B	6	20	12
24	3028	P	4	3	1	B	9	20	18
25	3060	P	4	5	1	B	9	40	18
26	3101	P	4	7	2	B	5	30	10
651	3060	P	4	5	1	B	12	20	24
27	3085	P	5	4	0	B	7	40	14
28	3085	P	5	4	0	B	7	40	14
30	3012	P	6	4	1	B	8	50	16
31	3051	P	6	6	2	B	15	40	30
32	3051	P	6	6	2	B	15	40	30
33	2981	P	8	1	1	B	11	40	22
34	3112	P	9	4	0	B	8	40	16
36	3132	P	9	5	0	B	9	40	18
348	3386	P	10	2	1	B	11	20	22
349	3386	P	10	2	1	B	12	40	24
350	3386	P	10	2	1	B	12	50	24
351	3386	P	10	2	1	B	14	70	28
367	3414	P	10	4	1	B	14	70	28
368	3469	P	10	5	1	B	8	20	16
369	3469	P	10	5	1	B	14	50	28
370	3444	P	11	5	1	B	14	70	28
347	3401	P	12	2	1	B	12	30	24
371	3431	P	12	3	1	B	11	30	22
372	3434	P	12	4	1	B	20	70	40
373	3491	P	12	5	1	B	11	70	22
374	3491	P	12	5	1	B	11	80	22
375	3491	P	12	5	1	B	11	80	22
384	3514	P	12	6	3	B	12	30	24
385	3511	P	12	5	1	B	11	40	22
391	3393	P	13	2	1	B	10	20	20
392	3410	P	13	4	1	B	10	11	20
394	3473	P	13	9	1	B	8	10	16
395	3461	P	13	8	1	B	11	70	22
398	3603	P	13	12	1	B	13	30	26
399	3603	P	13	12	1	B	8	50	16
400	3532	P	13	11	1	B	12	70	24
1	2913	P	1	1	1	R	7	80	14
2	2913	P	1	1	1	R	13	50	26
645	2193	P	1	1	1	R	12	30	24
29	3012	P	6	4	1	R	9	60	18
35	3132	P	9	5	0	R	7	30	14
37	3112	P	9	4	0	R	6	40	12
341	3379	P	10	1	1	R	9	30	18
342	3379	P	10	1	1	R	7	30	14
352	3386	P	10	2	1	R	10	40	20
353	3386	P	10	2	1	R	8	40	16
354	3386	P	10	2	1	R	8	50	16
355	3386	P	10	2	1	R	10	30	20
356	3386	P	10	2	1	R	7	20	14
357	3386	P	10	2	1	R	8	30	16
358	3386	P	10	2	1	R	13	60	26
359	3386	P	10	2	1	R	10	40	20
360	3386	P	10	2	1	R	8	40	16
361	3386	P	10	2	1	R	11	40	22

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
362	3386	P	10	2	1	R	8	30	16
366	3386	P	10	2	1	R	9	20	18
345	3374	P	12	1	1	R	9	40	18
346	3374	P	12	1	1	R	7	30	14
388	3370	P	13	1	1	R	20	10	40
389	3370	P	13	1	1	R	9	30	18
393	3473	P	13	9	1	R	8	40	16
397	3441	P	13	7	1	R	11	40	22
648	2948	P	1	2	1	W	5	30	10
649	2948	P	1	2	1	W	6	30	12
652	2949	P	6	2	1	W	11	30	22
653	2949	P	6	2	1	W	7	30	14
654	3051	P	6	6	2	W	7	40	14
343	3379	P	10	1	1	W	13	50	26
344	3379	P	10	1	1	W	6	40	12
386	3511	P	12	5	1	W	8	20	16
387	3370	P	13	1	1	W	14	20	28
390	3393	P	13	2	1	W	13	30	26
396	3441	P	13	7	1	W	10	80	20
401	3532	P	13	11	1	W	13	20	26
152	459	C	1	2	1	B	13	13	26
154	461	C	1	3	1	B	11	11	22
157	353	C	2	1	1	B	15	5	30
161	416	C	2	2	1	B	21	12	42
162	416	C	2	2	1	B	12	15	24
163	416	C	2	2	1	B	17	13	34
167	284	C	3	1	1	B	23	6	46
168	284	C	3	1	1	B	22	7	44
169	284	C	3	1	1	B	8	12	16
171	390	C	3	4	1	B	7	23	14
173	399	C	3	5	1	B	9	15	18
174	587	C	3	6	1	B	14	12	28
175	587	C	3	6	1	B	6	17.5	12
179	633	C	4	6	1	B	6	10	12
180	633	C	4	6	1	B	17	9	34
181	633	C	4	6	1	B	13	9	26
182	633	C	4	6	1	B	9	30	18
183	633	C	4	6	1	B	13	9	26
184	633	C	4	6	1	B	14	7	28
185	633	C	4	6	1	B	9	10	18

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
186	633	C	4	6	1	B	13	16	26
187	469	C	4	1	1	B	6	28	12
190	469	C	4	1	1	B	7	32	14
191	469	C	4	1	1	B	11	10	22
192	469	C	4	1	1	B	10	8	20
193	469	C	4	1	1	B	12	10	24
194	469	C	4	1	1	B	5	12	10
195	469	C	4	1	1	B	13	15	26
196	469	C	4	1	1	B	12	20	24
197	469	C	4	1	1	B	12	21	24
198	469	C	4	1	1	B	15	8	30
199	469	C	4	1	1	B	18	10	36
200	469	C	4	1	1	B	17	13	34
214	494	C	4	2	1	B	9	27	18
215	494	C	4	2	1	B	19	8	38
216	494	C	4	2	1	B	7	12	14
217	494	C	4	2	1	B	12	4	24
218	494	C	4	2	1	B	8	16	16
219	494	C	4	2	1	B	13	13	26
220	494	C	4	2	1	B	17	8	34
221	494	C	4	2	1	B	14	6	28
222	494	C	4	2	1	B	7	5	14
227	494	C	4	2	1	B	24	9	48
228	494	C	4	2	1	B	11	22	22
229	494	C	4	2	1	B	10	13	20
230	494	C	4	2	1	B	18	8	36
231	494	C	4	2	1	B	21	7	42
232	494	C	4	2	1	B	23	7	46
233	494	C	4	2	1	B	11	10	22
234	494	C	4	2	1	B	12	12	24
246	494	C	4	2	1	B	13	16	26
247	494	C	4	2	1	B	8	4	16
248	30	C	4	7	1	B	15	17	30
249	30	C	4	7	1	B	19	6	38
250	30	C	4	7	1	B	7	5	14
253	529	C	4	3	1	B	13	22	26
254	529	C	4	3	1	B	12	18	24
256	529	C	4	3	1	B	11	15	22
257	529	C	4	3	1	B	9	7	18
258	539	C	4	4	1	B	17	11	34

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
259	539	C	4	4	1	B	17	12	34
260	539	C	4	4	1	B	11	6	22
261	539	C	4	4	1	B	8	12	16
262	539	C	4	4	1	B	12	15	24
263	539	C	4	4	1	B	12	16	24
264	539	C	4	4	1	B	11	15	22
267	539	C	4	4	1	B	9	7	18
268	539	C	4	4	1	B	13	7	26
270	539	C	4	4	1	B	8	45	16
294	570	C	4	5	1	B	15	17	30
295	570	C	4	5	1	B	13	17	26
296	570	C	4	5	1	B	16	14	32
297	570	C	4	5	1	B	12	10	24
298	570	C	4	5	1	B	18	13	36
299	570	C	4	5	1	B	6	57	12
300	570	C	4	5	1	B	6	15	12
301	570	C	4	5	1	B	9	16	18
210	1003	C	5	4	1	B	17	40	34
211	1003	C	5	4	1	B	9	30	18
212	1003	C	5	4	1	B	12	20	24
213	1003	C	5	4	1	B	9	10	18
303	1045	C	5	5	1	B	10	40	20
304	1045	C	5	5	1	B	7	30	14
305	1045	C	5	5	1	B	9	10	18
306	1045	C	5	5	1	B	17	50	34
307	1045	C	5	5	1	B	6	20	12
308	1045	C	5	5	1	B	6	10	12
312	1089	C	5	7	1	B	10	60	20
313	1089	C	5	7	1	B	10	40	20
314	1089	C	5	7	1	B	15	30	30
315	1089	C	5	7	1	B	12	50	24
316	1089	C	5	7	1	B	14	40	28
317	1089	C	5	7	1	B	9	20	18
318	1089	C	5	7	1	B	9	20	18
319	1054	C	5	6	1	B	7	30	14
330	917	C	5	1	1	B	11	40	22
331	917	C	5	1	1	B	6	30	12
332	917	C	5	1	1	B	9	30	18
333	917	C	5	1	1	B	7	40	14
334	917	C	5	1	1	B	11	40	22

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
335	917	C	5	1	1	B	8	30	16
336	917	C	5	1	1	B	8	20	16
337	917	C	5	1	1	B	10	20	20
338	917	C	5	1	1	B	8	30	16
379	1347	C	6	6	4	B	8	20	16
425	1020	C	6	1	4	B	13	50	26
429	1495	C	6	10	4	B	12	70	24
431	1577	C	6	13	4	B	8	30	16
432	1577	C	6	13	4	B	9	50	18
433	1577	C	6	13	4	B	11	40	22
436	1220	C	6	2	4	B	13	40	26
437	1220	C	6	2	4	B	9	20	18
438	1267	C	6	3	4	B	8	30	16
439	1267	C	6	3	4	B	13	30	26
442	1228	C	6	1	7	B	11	60	22
443	1228	C	6	1	7	B	11	30	22
444	1228	C	6	1	7	B	11	40	22
445	1228	C	6	1	7	B	10	40	20
446	1228	C	6	1	7	B	10	50	20
452	1341	C	6	1	7	B	12	60	24
453	1341	C	6	1	7	B	12	50	24
454	969	C	7	1	1	B	11	50	22
461	1023	C	7	2	1	B	14	30	28
465	1023	C	7	2	1	B	11	40	22
466	1023	C	7	2	1	B	12	50	24
467	1023	C	7	2	1	B	9	50	18
472	1316	C	7	9	1	B	11	40	22
473	1316	C	7	9	1	B	11	30	22
475	1300	C	7	10	1	B	13	50	26
476	1060	C	8	1	1	B	8	20	16
477	1060	C	8	1	1	B	9	20	18
480	5.6	C	8	7	1	B	11	40	22
481	1286	C	8	7	1	B	10	30	20
482	1578	C	8	12	1	B	12	60	24
483	1578	C	8	12	1	B	16	60	32
485	1578	C	8	12	1	B	7	40	14
486	1583	C	8	12	1	B	16	60	32
487	2285	C	8	6	3	B	11	40	22
492	2196	C	8	5	3	B	11	30	22
495	2376	C	8	7	3	B	12	70	24

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
496	1413	C	9	3	1	B	17	50	34
507	1277	C	9	1	1	B	12	60	24
508	1277	C	9	1	1	B	11	40	22
509	1277	C	9	1	1	B	11	60	22
510	1277	C	9	1	1	B	12	40	24
511	1375	C	9	2	1	B	14	40	28
512	1375	C	9	2	1	B	14	30	28
514	1407	C	10	4	1	B	10	40	20
515	1407	C	10	4	1	B	11	20	22
516	1407	C	10	4	1	B	11	20	22
517	1387	C	10	3	1	B	10	20	20
518	1387	C	10	3	1	B	12	20	24
519	1380	C	10	2	1	B	10	50	20
523	1393	C	11	2	1	B	11	30	22
102	1932	C	12	3	1	B	9	60	18
110	2215	C	12	8	1	B	12	60	24
111	2215	C	12	8	1	B	8	50	16
112	2110	C	12	6	1	B	11	40	22
113	2110	C	12	6	1	B	10	50	20
114	2110	C	12	6	1	B	10	40	20
524	1873	C	12	1	1	B	13	30	26
106	1857	C	13	1	1	B	13	50	26
119	1990	C	13	1	4	B	14	50	28
537	2013	C	13	2	1	B	12	30	24
540	2526	C	13	7	4	B	13	50	26
541	2526	C	13	7	4	B	12	40	24
121	2071	C	15	2	1	B	13	50	26
122	2071	C	15	2	1	B	14	50	28
123	2071	C	15	2	1	B	9	30	18
124	2071	C	15	2	1	B	9	30	18
125	2071	C	15	2	1	B	10	50	20
126	2071	C	15	2	1	B	9	40	18
127	2071	C	15	2	1	B	9	50	18
128	2071	C	15	2	1	B	10	40	20
129	2071	C	15	2	1	B	9	30	18
132	2317	C	15	4	1	B	10	50	20
133	2317	C	15	4	1	B	10	60	20
134	2317	C	15	4	1	B	10	40	20
135	2317	C	15	4	1	B	10	70	20
136	2317	C	15	4	1	B	11	50	22

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
140	2179	C	15	3	1	B	12	40	24
141	2179	C	15	3	1	B	12	60	24
142	2179	C	15	3	1	B	10	40	20
143	2179	C	15	3	1	B	12	40	24
144	2179	C	15	3	1	B	12	40	24
145	2179	C	15	3	1	B	13	50	26
146	2179	C	15	3	1	B	10	40	20
147	2179	C	15	3	1	B	10	40	20
148	2179	C	15	3	1	B	10	50	20
149	2179	C	15	3	1	B	11	30	22
150	2179	C	15	3	1	B	13	50	26
552	2239	C	16	2	1	B	9	30	18
553	2239	C	16	2	1	B	12	40	24
560	2450	C	16	5	1	B	12	30	24
561	2450	C	16	5	1	B	11	30	22
562	2450	C	16	5	1	B	12	30	24
563	2450	C	16	5	1	B	10	40	20
564	2573	C	16	7	1	B	8	40	16
565	2573	C	16	7	1	B	10	30	20
566	2573	C	16	7	1	B	11	40	22
567	2573	C	16	7	1	B	6	50	12
568	2573	C	16	7	1	B	9	30	18
569	2573	C	16	7	1	B	16	60	32
570	2573	C	16	7	1	B	18	40	36
571	2573	C	16	7	1	B	15	40	30
572	2573	C	16	7	1	B	15	60	30
573	2573	C	16	7	1	B	8	60	16
574	2573	C	16	7	1	B	12	50	24
575	2573	C	16	7	1	B	11	40	22
576	2573	C	16	7	1	B	12	40	24
577	2573	C	16	7	1	B	12	50	24
578	2573	C	16	7	1	B	11	30	22
579	2573	C	16	7	1	B	10	40	20
580	2573	C	16	7	1	B	15	60	30
588	2615	C	16	10	1	B	9	40	18
589	2615	C	16	10	1	B	12	30	24
590	2615	C	16	10	1	B	12	50	24
591	2615	C	16	10	1	B	11	50	22
602	2519	C	16	6	1	B	11	30	22
603	2519	C	16	6	1	B	6	40	12

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
604	2519	C	16	6	1	B	5	50	10
605	2519	C	16	6	1	B	7	40	14
606	2519	C	16	6	1	B	6	50	12
607	2519	C	16	6	1	B	8	50	16
609	2519	C	16	6	1	B	8	40	16
610	2519	C	16	6	1	B	8	30	16
611	2519	C	16	6	1	B	11	20	22
612	2519	C	16	6	1	B	11	50	22
613	2519	C	16	6	1	B	8	30	16
614	2519	C	16	6	1	B	12	50	24
615	2367	C	17	1	1	B	10	20	20
631	2597	C	17	6	1	B	9	30	18
632	2597	C	17	6	1	B	14	40	28
633	2597	C	17	6	1	B	14	50	28
634	2597	C	17	6	1	B	13	30	26
635	2597	C	17	6	1	B	11	30	22
636	2562	C	17	5	1	B	13	50	26
637	2562	C	17	5	1	B	6	30	12
638	2562	C	17	5	1	B	7	40	14
639	2562	C	17	5	1	B	8	30	16
644	2437	C	17	3	1	B	10	30	20
647	2564	C	17	5	1	B	10	40	20
151	459	C	1	2	1	R	9	12	18
153	459	C	1	2	1	R	15	3	30
155	462	C	1	3	1	R	9	12	18
164	7	C	2	4	1	R	15	30	30
165	284	C	3	1	1	R	16	11	32
172	399	C	3	5	1	R	8	40	16
188	469	C	4	1	1	R	12	13	24
189	469	C	4	1	1	R	14	4	28
205	469	C	4	1	1	R	22	8	44
206	469	C	4	1	1	R	24	3	48
225	494	C	4	2	1	R	15	10	30
226	494	C	4	2	1	R	16	15	32
235	494	C	4	2	1	R	11	14	22
236	494	C	4	2	1	R	14	4	28
237	494	C	4	2	1	R	11	6	22
251	529	C	4	3	1	R	6	10	12
269	539	C	4	4	1	R	19	20	38
271	539	C	4	4	1	R	9	19	18

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
272	539	C	4	4	1	R	9	24	18
273	539	C	4	4	1	R	15	17	30
287	570	C	4	5	1	R	8	34	16
207	1003	C	5	4	1	R	18	40	36
309	1045	C	5	5	1	R	10	70	20
310	974	C	5	3	1	R	14	50	28
326	917	C	5	1	1	R	9	70	18
327	917	C	5	1	1	R	11	40	22
328	917	C	5	1	1	R	8	40	16
329	917	C	5	1	1	R	6	20	12
377	986	C	6	1	3	R	10	30	20
378	1347	C	6	6	4	R	11	30	22
382	928	C	6	1	1	R	17	30	34
383	928	C	6	1	1	R	11	60	22
426	1020	C	6	1	4	R	13	80	26
428	1434	C	6	9	4	R	13	40	26
434	1220	C	6	2	4	R	14	70	28
441	1061	C	6	1	5	R	16	60	32
450	1228	C	6	1	7	R	9	40	18
457	969	C	7	1	1	R	13	70	26
458	1023	C	7	2	1	R	13	40	26
459	1023	C	7	2	1	R	12	50	24
460	1023	C	7	2	1	R	15	60	30
468	1064	C	7	3	1	R	15	70	30
470	1186	C	7	6	1	R	12	30	24
478	1060	C	8	1	1	R	11	30	22
491	2196	C	8	5	3	R	11	40	22
493	2376	C	8	7	3	R	16	30	32
494	2376	C	8	7	3	R	10	20	20
497	1277	C	9	1	1	R	14	50	28
498	1277	C	9	1	1	R	10	20	20
499	1277	C	9	1	1	R	13	20	26
500	1277	C	9	1	1	R	12	40	24
501	1277	C	9	1	1	R	9	30	18
502	1277	C	9	1	1	R	12	20	24
503	1277	C	9	1	1	R	14	30	28
504	1277	C	9	1	1	R	13	30	26
520	1396	C	11	3	1	R	15	60	30
103	1932	C	12	3	1	R	9	50	18
104	1932	C	12	3	1	R	13	60	26

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
107	1903	C	12	2	1	R	11	40	22
108	2215	C	12	8	1	R	9	40	18
109	2215	C	12	8	1	R	8	50	16
115	2110	C	12	6	1	R	9	40	18
525	1873	C	12	1	1	R	11	30	22
105	1857	C	13	1	1	R	10	40	20
116	2337	C	13	5	4	R	12	70	24
117	1990	C	13	1	4	R	10	50	20
118	1990	C	13	1	4	R	10	40	20
120	2071	C	15	2	1	R	11	50	22
130	2317	C	15	4	1	R	14	60	28
131	2317	C	15	4	1	R	12	50	24
137	2179	C	15	3	1	R	11	50	22
138	2179	C	15	3	1	R	13	40	26
139	2179	C	15	3	1	R	10	40	20
554	2901	C	16	4	1	R	13	30	26
555	2450	C	16	5	1	R	13	30	26
556	2450	C	16	5	1	R	15	40	30
586	2573	C	16	7	1	R	10	30	20
587	2573	C	16	7	1	R	9	40	18
594	2615	C	16	10	1	R	8	30	16
595	2615	C	16	10	1	R	14	40	28
599	2519	C	16	6	1	R	8	30	16
600	2519	C	16	6	1	R	10	20	20
601	2519	C	16	6	1	R	10	40	20
617	2367	C	17	1	1	R	9	20	18
618	2395	C	17	2	1	R	10	30	20
619	2395	C	17	2	1	R	13	40	26
620	2395	C	17	2	1	R	16	40	32
621	2395	C	17	2	1	R	11	20	22
622	2597	C	17	6	1	R	11	40	22
623	2597	C	17	6	1	R	14	50	28
624	2597	C	17	6	1	R	8	40	16
625	2597	C	17	6	1	R	11	20	22
640	2562	C	17	5	1	R	12	30	24
643	2437	C	17	3	1	R	8	20	16
156	353	C	2	1	1	W	4	55	8
158	353	C	2	1	1	W	7	13	14
159	353	C	2	1	1	W	7	10	14
160	416	C	2	2	1	W	15	13	30

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
166	284	C	3	1	1	W	9	17	18
170	347	C	3	2	1	W	15	10	30
176	633	C	4	6	1	W	8	20	16
177	633	C	4	6	1	W	16	12	32
201	469	C	4	1	1	W	12	5	24
202	469	C	4	1	1	W	5	35	10
203	469	C	4	1	1	W	5	17	10
204	469	C	4	1	1	W	7	35	14
223	494	C	4	2	1	W	7	13	14
224	494	C	4	2	1	W	12	11	24
238	494	C	4	2	1	W	23	4	46
239	494	C	4	2	1	W	7	9	14
240	494	C	4	2	1	W	10	4	20
241	494	C	4	2	1	W	6	19	12
242	494	C	4	2	1	W	8	16	16
243	494	C	4	2	1	W	7	11	14
244	494	C	4	2	1	W	10	23	20
245	494	C	4	2	1	W	15	4	30
252	529	C	4	3	1	W	5	50	10
255	529	C	4	3	1	W	8	20	16
274	539	C	4	4	1	W	20	30	40
275	539	C	4	4	1	W	18	40	36
276	539	C	4	4	1	W	11	5	22
277	539	C	4	4	1	W	16	20	32
278	539	C	4	4	1	W	15	29	30
279	539	C	4	4	1	W	13	24	26
280	539	C	4	4	1	W	13	16	26
281	539	C	4	4	1	W	10	20	20
282	539	C	4	4	1	W	4	25	8
283	539	C	4	4	1	W	4	55	8
284	539	C	4	4	1	W	9	13	18
285	539	C	4	4	1	W	7	9	14
286	539	C	4	4	1	W	6	47	12
288	570	C	4	5	1	W	13	23	26
289	570	C	4	5	1	W	11	23	22
290	570	C	4	5	1	W	6	25	12
291	570	C	4	5	1	W	5	25	10
292	570	C	4	5	1	W	9	8	18
293	570	C	4	5	1	W	15	10	30
302	570	C	4	5	1	W	3	40	6

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
208	1003	C	5	4	1	W	7	20	14
209	1003	C	5	4	1	W	9	20	18
311	974	C	5	3	1	W	14	40	28
320	1054	C	5	6	1	W	10	30	20
321	1054	C	5	6	1	W	8	40	16
322	1054	C	5	6	1	W	9	20	18
323	917	C	5	1	1	W	12	30	24
324	917	C	5	1	1	W	6	20	12
325	917	C	5	1	1	W	13	30	26
380	1347	C	6	6	4	W	9	20	18
381	1392	C	6	7	4	W	10	10	20
427	1020	C	6	1	4	W	15	50	30
430	1499	C	6	11	4	W	12	60	24
435	1220	C	6	2	4	W	10	40	20
440	1267	C	6	3	4	W	12	40	24
447	1228	C	6	1	7	W	8	40	16
448	1228	C	6	1	7	W	8	50	16
449	1228	C	6	1	7	W	8	20	16
451	1341	C	6	1	7	W	12	40	24
455	969	C	7	1	1	W	13	30	26
456	969	C	7	1	1	W	12	80	24
462	1023	C	7	2	1	W	10	30	20
463	1023	C	7	2	1	W	7	50	14
464	1023	C	7	2	1	W	6	50	12
469	1247	C	7	8	1	W	11	40	22
471	1316	C	7	9	1	W	9	40	18
474	1604	C	7	12	1	W	10	50	20
479	1242	C	8	5	1	W	14	30	28
484	1578	C	8	12	1	W	9	30	18
488	2285	C	8	6	3	W	13	30	26
489	2196	C	8	5	3	W	10	40	20
490	2196	C	8	5	3	W	10	40	20
505	1277	C	9	1	1	W	16	50	32
506	1277	C	9	1	1	W	13	30	26
513	1504	C	9	4	1	W	4	20	8
521	1393	C	11	2	1	W	8	20	16
522	1393	C	11	2	1	W	4	20	8
526	1903	C	12	2	1	W	12	60	24
527	1903	C	12	2	1	W	11	60	22
528	1903	C	12	2	1	W	12	60	24

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
529	1903	C	12	2	1	W	12	40	24
530	1903	C	12	2	1	W	14	50	28
531	1903	C	12	2	1	W	14	50	28
532	2110	C	12	6	1	W	15	60	30
533	2110	C	12	6	1	W	13	60	26
534	2215	C	12	8	1	W	14	30	28
535	2215	C	12	8	1	W	11	40	22
536	2215	C	12	8	1	W	7	20	14
538	2172	C	13	3	4	W	11	20	22
539	2172	C	13	3	4	W	9	40	18
542	2071	C	15	2	1	W	10	30	20
543	2071	C	15	2	1	W	12	30	24
544	2071	C	15	2	1	W	13	30	26
545	2179	C	15	3	1	W	12	40	24
546	2179	C	15	3	1	W	9	40	18
547	2179	C	15	3	1	W	8	40	16
548	2179	C	15	3	1	W	7	40	14
549	2179	C	15	3	1	W	10	40	20
550	2179	C	15	3	1	W	11	40	22
551	2317	C	15	4	1	W	11	30	22
557	2450	C	16	5	1	W	13	20	26
558	2450	C	16	5	1	W	12	30	24
559	2450	C	16	5	1	W	7	40	14
581	2573	C	16	7	1	W	10	40	20
582	2573	C	16	7	1	W	7	40	14
583	2573	C	16	7	1	W	15	50	30
584	2573	C	16	7	1	W	10	30	20
585	2573	C	16	7	1	W	7	60	14
592	2615	C	16	10	1	W	7	40	14
593	2615	C	16	10	1	W	11	50	22
596	2519	C	16	6	1	W	11	60	22
597	2519	C	16	6	1	W	12	40	24
598	2519	C	16	6	1	W	12	40	24
616	2367	C	17	1	1	W	8	30	16
626	2597	C	17	6	1	W	9	30	18
627	2597	C	17	6	1	W	7	30	14
628	2597	C	17	6	1	W	10	30	20
629	2597	C	17	6	1	W	11	50	22
630	2597	C	17	6	1	W	11	50	22
641	2562	C	17	5	1	W	6	50	12

ID #	Sp #	S	U	L	L	W	R (cm)	Deg Arc	Dm (cm)
642	2437	C	17	3	1	W	8	20	16

APPENDIX F: Whole Vessel Data, Museum Collections

(Mu=Museum, Wr=Ware, Rd=Rim Diameter, Bd=Base Diameter, Ht=Height, R=Radius, CV1=Calculated Volume 1, CV2=Calculated Volume 2, W=Western New Mexico, LA=Lab of Anthropology, CH=Chicago, NM=University of New Mexico, BR=Brown, RD=Red, WH=White)

ID#	Mu	WR	Rd	Bd	Ht	R	CV1	CV2
1	W	BR	17	7	10	5	1173	1286
2	W	BR	12	5	6	6	452	452
3	W	BR	23	9	13	6	2750	2982
4	W	BR	27	7	16	7	4366	4872
5	W	BR	18	8	10	8	1442	1527
6	NM	BR	11	7	8	7	269	348
7	W	BR	22		4	6	3419	2602
11	W	BR	22	9	14	5	2209	2602
14	W	BR	15	7	10	5	736	884
15	W	BR	21	10	12	6	2251	2425
16	W	BR	19	10	10	5	1748	1796
17	W	BR	12	5	6	5	452	452
18	W	BR	24	8	15	6	3167	3619
19	W	BR	10	7	6	5	236	262
20	W	BR	26	8	12	5	4778	4601
21	W	BR	20	7	9	6	2199	2094
22	W	BR	17	8	8	5	1324	1286
23	W	BR	19	8	8	5	1937	1796
24	W	BR	18	8	8	6	1612	1527
25	W	BR	12	8	9	5	339	452
26	W	BR	24	na	10	6	3921	3619
27	W	BR	16	7	13	7	737	1072
28	W	BR	16	7	9	4	1005	1072
29	W	BR	24	na	10	5	3921	3619
30	W	BR	19	7	10	7	1748	1796
32	W	BR	25	10	11	8	4336	4091
33	W	BR	28	9	12	6	5791	5445
34	W	BR	19	na	8	5	1937	1796
38	W	BR	28	4	11	6	5989	5445
39	W	BR	13	5	9	6	465	575
40	W	BR	11	6	7	5	301	348
42	W	BR	15	6	8	5	854	884
43	W	BR	15	9	8	5	854	884
44	W	BR	11	6	7	6	301	348
45	W	BR	21	10	11	7	2367	2425
46	W	BR	21	10	12	7	2063	2255
47	W	BR	25	9	10	6	4204	3850
48	W	BR	13	5	8	6	460	511
49	W	BR	10	4	7	6	223	262
50	W	BR	16	5	7	6	1139	1072
51	W	BR	22	9	12	8	2661	2788
64	W	BR	20	10	7	6	2409	2094
65	W	BR	20	11	8	5	2304	2094
66	W	BR	27	9	17	6	4485	5153
67	W	BR	28	9	16		5337	5747
68	W	BR	17	9	7	6	1301	1176
69	W	BR	14	4	7	6	632	644
70	W	BR	27	8	17	5	4183	4872
71	W	BR	12	4	7	6	355	398
85	NM	BR	15	7	6	5	972	884
86	NM	BR	18	8	9	6	1527	1527
87	NM	BR	18	6	8	5	1463	1403
88	NM	BR	17	12	11	6	980	1176
89	NM	BR	21	8	12	5	2251	2425
90	NM	BR	16	6	8	4	1106	1072
91	NM	BR	31	13	12	7	8219	7428
93	NM	BR	20	6	13	5	1833	2094
94	NM	BR	22	8	9	6	2814	2602
95	NM	BR	20	10	10	6	2094	2094
96	NM	BR	33	12	20	5	7950	8987
97	NM	BR	29	10	16	6	6055	6385
98	NM	BR	25	10	13	5	4009	4091
99	NM	BR	20	9	11	6	1990	2094
134	NM	BR	23	9	12	7	3116	3185
135	NM	BR	22	10	13	6	2390	2602
180	LA	BR	17	8	8	8	1324	1286
181	LA	BR	24	10	14	6	3318	3619
182	LA	BR	20	11	12	6	1717	1941
183	LA	BR	19	10	9	5	1680	1658
184	LA	BR	26	13	15	7	4247	4601
185	LA	BR	20	7	12	6	1717	1941
186	LA	BR	22	15	12	7	2451	2602
187	LA	BR	22	10	15	5	2281	2788
188	LA	BR	27	13	16	7	4366	4872
189	LA	BR	18	14	9	5	1383	1403
190	LA	BR	16	8	9	5	896	975
191	LA	BR	21	8	12	7	2251	2425
192	LA	BR	17	10	8	5	1194	1176
193	LA	BR	15	10	8	7	884	884
194	LA	BR	15	7	9	5	825	884
195	LA	BR	11	8	6	5	348	348
196	LA	BR	15	8	7	5	812	798
204	LA	BR	19	9	10	4	1590	1658
206	LA	BR	12	8	7	6	415	452
209	LA	BR	18	10	13	5	1188	1527
218	LA	BR	17	9	11	6	980	1176
219	LA	BR	25	13	15	6	3682	4091
220	LA	BR	18	9	9	5	1383	1403
221	LA	BR	18	9	11	5	1357	1527
222	LA	BR	14	6	7	5	718	718
223	LA	BR	18	8	10	7	1303	1403
224	LA	BR	14	10	6	6	680	644
225	LA	BR	19	10	12	5	1607	1796
226	LA	BR	15	7	8	5	854	884
227	LA	BR	25	12	13	5	3811	3850
229	LA	BR	13	11	9	4	465	575
230	LA	BR	29	19	19		5394	6385
231	CH	BR	15	9	12	5	537	798
232	CH	BR	15	12	9	5	702	798
234	CH	BR	31	10	19	6	6515	7428
246	CH	BR	27	14	13	4	5248	5153
249	CH	BR	18	12	10	3	1442	1527
250	CH	BR	13	6	9	4	465	575
251	CH	BR	21	7	9	5	2598	2425
254	CH	BR	38	16	17	7	15122	14365

ID#	Mu	WR	Rd	Bd	Ht	R	CV1	CV2
262	CH	BR	29	10	15	6	6275	6385
263	CH	BR	27	9	17	5	4485	5153
264	CH	BR	14	6	8	3	667	718
265	CH	BR	8	4	5	3	92	110
268	CH	BR	18	9	11	4	1357	1527
284	CH	BR	21	12	19	5	1443	2425
293	CH	BR	25	11	13	6	3732	3850
294	CH	BR	24	10	14	4	3318	3619
295	CH	BR	15	8	9	5	795	884
296	CH	BR	15	6	9	4	795	884
297	CH	BR	15	7	6	4	972	884
298	CH	BR	12	5	8	4	377	452
299	CH	BR	26	13	13	4	4601	4601
300	CH	BR	31	9	17	7	7422	7799
301	CH	BR	22	12	11	5	2788	2788
302	CH	BR	20	11	10	5	2094	2094
78	WN	RD	22	9	11	8	2788	2788
79	WN	RD	22	7	12	6	2661	2788
100	NM	RD	22	8	11	4	2572	2602
101	NM	RD	14	8	8	5	693	718
102	NM	RD	13	5	6	5	542	511
103	NM	RD	25	10	12	6	3889	3850
104	NM	RD	28	11	13	7	5952	5747
105	NM	RD	23	8	11	6	3015	2982
106	NM	RD	10	4	5	4	262	262
107	NM	RD	28	10	11	6	5989	5445
108	NM	RD	21	7	11	5	2367	2425
109	NM	RD	25	9	13	6	3732	3850
110	NM	RD	12	7	8	4	377	452
111	NM	RD	18	7	9	5	1383	1403
112	NM	RD	19	9	11	6	1546	1658
113	NM	RD	23	7	12	6	3116	3185
114	NM	RD	31	10	15	6	7489	7428
119	NM	RD	16	7	9	6	1039	1072
120	NM	RD	20	8	11	8	1990	2094
121	NM	RD	24	10	12	6	3361	3398
122	NM	RD	23	8	11	6	3081	2982
136	NM	RD	18	8	11	6	1223	1403
137	NM	RD	20	17	7	6	2461	2094
138	NM	RD	17	11	7	5	1438	1286
146	NM	RD	23	14	12	4	3116	3185
151	NM	RD	26	11	14	6	4128	4341
152	NM	RD	21	10	12	7	2118	2255
153	NM	RD	15	9	8	6	884	884
154	NM	RD	19	10	10	6	1590	1658
155	NM	RD	30	13	19	6	6126	7069
156	NM	RD	20	10	11	6	2042	2094
157	NM	RD	18	11	11	6	1357	1527
158	NM	RD	31	12	17	6	7002	7428
161	LA	RD	26	10	14	6	4128	4341
162	LA	RD	24	11	15	6	2928	3398
163	LA	RD	24	11	15	5	3167	3619
164	LA	RD	26	10	14	6	4424	4601
165	LA	RD	25	12	14	5	3575	3850
166	LA	RD	26	14	15	7	4247	4601
167	LA	RD	26	11	15	6	4247	4601
168	LA	RD	18	8	10	5	1442	1527
169	LA	RD	28	13	15	6	5542	5747
170	LA	RD	24	9	13	5	3289	3398

ID#	Mu	WR	Rd	Bd	Ht	R	CV1	CV2
171	LA	RD	31	14	18	7	7170	7799
172	LA	RD	29	16	18	6	5614	6385
174	LA	RD	28	13	15	6	5542	5747
179	LA	RD	29	12	17	6	5835	6385
197	LA	RD	22	12	13	4	2534	2788
198	LA	RD	24	10	15	6	3167	3619
199	LA	RD	21	10	12	6	2251	2425
200	LA	RD	25	11	14	4	3845	4091
201	LA	RD	31	14	18	5	6758	7428
202	LA	RD	12	7	9	5	339	452
203	LA	RD	24	13	18	6	2714	3619
205	LA	RD	16	9	14	6	613	975
235	CH	RD	25	10	14	6	3845	4091
236	CH	RD	15	8	9	5	795	884
237	CH	RD	26	13	13	6	4601	4601
238	CH	RD	25	11	13	7	4009	4091
239	CH	RD	25	13	13	5	4009	4091
240	CH	RD	25	12	13	6	4009	4091
241	CH	RD	24	9	13	5	3468	3619
242	CH	RD	25	10	12	7	4172	4091
243	CH	RD	18	10	9	6	1527	1527
244	CH	RD	18	10	10	6	1442	1527
245	CH	RD	21	6	14	4	2020	2425
247	CH	RD	12	6	7	4	415	452
248	CH	RD	24	12	12	6	3619	3619
256	CH	RD	16	10	9	5	1005	1072
257	CH	RD	20	12	10	6	2094	2094
258	CH	RD	25	9	15	7	3682	4091
261	CH	RD	30	10	17	6	6597	7069
267	CH	RD	20	9	13	4	1780	2094
269	CH	RD	16	6	10	4	972	1072
270	CH	RD	15	8	13	6	560	884
271	CH	RD	16	9	9	5	1005	1072
272	CH	RD	32	18	16	6	8118	8183
273	CH	RD	20	10	10	6	2094	2094
285	CH	RD	22	11	12	5	2451	2602
286	CH	RD	24	10	12	5	3619	3619
287	CH	RD	24	14	11	6	3770	3619
288	CH	RD	24	15	11	6	3770	3619
289	CH	RD	15	6	5	5	922	798
290	CH	RD	25	13	14	6	3575	3850
292	CH	RD	22	15	11	6	2572	2602
305	CH	RD	23	11	11	5	3255	3185
306	CH	RD	28	13	14	5	5747	5747
308	CH	RD	29	16	16	6	6055	6385
309	CH	RD	19	9	11	4	1501	1658
310	CH	RD	22	13	11	5	2788	2788
123	NM	WH	23	14	13	4	2978	3185
124	NM	WH	23	9	14	4	2908	3185
125	NM	WH	20	13	5	5	2618	2094
126	NM	WH	12	4	5	4	490	452
127	NM	WH	20	8	11	4	1990	2094
128	NM	WH	15	9	5	5	922	798
266	CH	WH	12	6	8	3	377	452
274	CH	WH	28	11	14	5	5747	5747
277	CH	WH	22	7	12	4	2661	2788
278	CH	WH	28	13	14	4	5747	5747
279	CH	WH	22	9	14	5	2471	2788
280	CH	WH	25	10	13	5	4009	4091

ID#	Mu	WR	Rd	Bd	Ht	R	CV1	CV2
281	CH	WH	16	6	10	6	972	1072
282	CH	WH	17	9	10	4	1087	1176
283	CH	WH	22	9	12		2451	2602
291	CH	WH	21	10	11	6	2367	2425

APPENDIX G: Sherd Refiring Data,

Cox Ranch Pueblo (GH=Great House, M=Midden)

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
1	76	2562	GH	17	5	1	Brown	2.5YR5/6	1	Red
2	77	2562	GH	17	5	1	Brown	2.5YR5/8	1	Red
3	78	2562	GH	17	5	1	Brown	2.5YR6/6	1	Red
4	79	2562	GH	17	5	1	Brown	5YR5/6	1	Red
5	80	2562	GH	17	5	1	Brown	2.5YR5/6	1	Red
6	81	2562	GH	17	5	1	Brown	2.5YR5/8	1	Red
7	82	2562	GH	17	5	1	Brown	5YR5/6	1	Red
8	83	74	M15	2	2	1	Brown	5YR7/6	1	Red
9	84	74	M15	2	2	1	Brown	2.5YR5/6	1	Red
10	85	74	M15	2	2	1	Brown	7.5YR5/6	1	Red
11	86	74	M15	2	2	1	Brown	2.5YR5/6	1	Red
12	87	74	M15	2	2	1	Brown	2.5YR5/8	1	Red
13	88	74	M15	2	2	1	Brown	2.5YR5/6	1	Red
14	89	74	M15	2	2	1	Brown	5YR5/6	1	Red
15	90	74	M15	2	2	1	Brown	2.5YR5/6	1	Red
16	91	74	M15	2	2	1	Brown	2.5YR5/8	1	Red
17	92	74	M15	2	2	1	Brown	5YR5/6	1	Red
18	93	74	M15	2	2	1	Brown	2.5YR5/6	1	Red
19	94	916	M13	5	1	1	Brown	2.5YR6/8	1	Red
20	95	916	M13	5	1	1	Brown	2.5YR5/8	1	Red
21	96	916	M13	5	1	1	Brown	2.5YR5/6	1	Red
22	97	916	M13	5	1	1	Brown	2.5YR6/6	1	Red
23	98	916	M13	5	1	1	Brown	5YR5/6	1	Red
24	99	916	M13	5	1	1	Brown	5YR5/8	1	Red
25	100	916	M13	5	1	1	Brown	2.5YR5/6	1	Red
26	101	916	M13	5	1	1	Brown	5YR6/6	1	Red
27	102	916	M13	5	1	1	Brown	2.5YR6/8	1	Red
28	103	916	M13	5	1	1	Brown	5YR5/6	1	Red
29	104	916	M13	5	1	1	Brown	2.5YR5/6	1	Red
30	105	1801	M6	2	2	1	Brown	2.5YR5/6	1	Red
31	106	1801	M6	2	2	1	Brown	5YR5/6	1	Red
32	107	1801	M6	2	2	1	Brown	5YR5/6	1	Red
33	108	1801	M6	2	2	1	Brown	2.5YR6/8	1	Red
34	109	1801	M6	2	2	1	Brown	2.5YR5/6	1	Red
35	110	1801	M6	2	2	1	Brown	2.5YR5/6	1	Red

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
36	111	1801	M6	2	2	1	Brown	2.5YR6/8	1	Red
37	112	1801	M6	2	2	1	Brown	5YR4/6	1	Red
38	113	1801	M6	2	2	1	Brown	5YR6/8	1	Red
39	114	1801	M6	2	2	1	Brown	5YR6/8	1	Red
40	115	1779	M6	4	2	1	Brown	5YR5/6	1	Red
41	116	1779	M6	4	2	1	Brown	5YR6/6	1	Red
42	117	1779	M6	4	2	1	Brown	5YR5/8	1	Red
43	118	1981	GH	15	1	1	Brown	5YR4/8	1	Red
44	119	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
45	120	1981	GH	15	1	1	Brown	5YR5/6	1	Red
46	121	1981	GH	15	1	1	Brown	5YR4/6	1	Red
47	122	1981	GH	15	1	1	Brown	2.5YR4/8	1	Red
48	123	1981	GH	15	1	1	Brown	2.5YR4/8	1	Red
49	124	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
50	125	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
51	126	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
52	127	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
53	128	1981	GH	15	1	1	Brown	5YR4/6	1	Red
54	129	1981	GH	15	1	1	Brown	5YR56	1	Red
55	130	1981	GH	15	1	1	Brown	2.5YR5/8	1	Red
56	131	1981	GH	15	1	1	Brown	2.5YR5/8	1	Red
57	132	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
58	133	1981	GH	15	1	1	Brown	5YR5/6	1	Red
59	134	1981	GH	15	1	1	Brown	2.5YR4/6	1	Red
60	135	1981	GH	15	1	1	Brown	2.5YR4/6	1	Red
61	136	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
62	137	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
63	138	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
64	139	1981	GH	15	1	1	Brown	2.5YR4/6	1	Red
65	140	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
66	141	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
67	142	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
68	143	1981	GH	15	1	1	Brown	5YR5/6	1	Red
69	144	1981	GH	15	1	1	Brown	2.5YR4/6	1	Red
70	145	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
71	146	1981	GH	15	1	1	Brown	2.5YR5/6	1	Red
72	147	1981	GH	15	1	1	Brown	5YR5/8	1	Red

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
73	148	2588	GH	16	8	1	Brown	2.5YR5/6	1	Red
74	149	2588	GH	16	8	1	Brown	2.5YR5/6	1	Red
75	150	2588	GH	16	8	1	Brown	2.5YR5/6	1	Red
76	151	2588	GH	16	8	1	Brown	2.5YR5/8	1	Red
77	152	2588	GH	16	8	1	Brown	2.5YR5/8	1	Red
78	153	2588	GH	16	8	1	Brown	2.5YR5/8	1	Red
79	154	2588	GH	16	8	1	Brown	5YR4/6	1	Red
80	155	2588	GH	16	8	1	Brown	2.5YR5/8	1	Red
81	156	2588	GH	16	8	1	Brown	2.5YR5/8	1	Red
82	157	2588	GH	16	8	1	Brown	2.5YR4/8	1	Red
83	158	2588	GH	16	8	1	Brown	2.5YR5/6	1	Red
84	159	2588	GH	16	8	1	Brown	2.5YR5/8	1	Red
85	160	2588	GH	16	8	1	Brown	5YR5/4	1	Red
86	161	2607	GH	16	9	1	Brown	5YR5/6	1	Red
87	162	2607	GH	16	9	1	Brown	2.5YR5/6	1	Red
88	163	2607	GH	16	9	1	Brown	2.5YR5/8	1	Red
89	164	2607	GH	16	9	1	Brown	2.5YR4/8	1	Red
90	165	2607	GH	16	9	1	Brown	2.5YR4/8	1	Red
91	166	2607	GH	16	9	1	Brown	2.5YR4/8	1	Red
92	167	2607	GH	16	9	1	Brown	2.5YR5/8	1	Red
93	168	2607	GH	16	9	1	Brown	2.5YR4/8	1	Red
94	169	2607	GH	16	9	1	Brown	5YR4/6	1	Red
95	170	2607	GH	16	9	1	Brown	5YR4/6	1	Red
96	171	2607	GH	16	9	1	Brown	2.5YR5/8	1	Red
97	172	1775	M11	1	2	1	Brown	2.5YR5//8	1	Red
98	173	1775	M11	1	2	1	Brown	2.5YR5/8	1	Red
99	174	1775	M11	1	2	1	Brown	5YR5/6	1	Red
100	175	1775	M11	1	2	1	Brown	5YR4/6	1	Red
101	176	1775	M11	1	2	1	Brown	5YR4/6	1	Red
102	177	1775	M11	1	2	1	Brown	2.5YR4/8	1	Red
103	178	1775	M11	1	2	1	Brown	5YR4/6	1	Red
104	179	1775	M11	1	2	1	Brown	5YR4/6	1	Red
105	180	1775	M11	1	2	1	Brown	2.5YR4/8	1	Red
106	181	1775	M11	1	2	1	Brown	2.5YR4/8	2	Yellow-Red
107	182	2430	GH	15	5	1	Brown	2.5YR5/6	2	Yellow-Red
108	183	2430	GH	15	5	1	Brown	2.5YR5/8	2	Yellow-Red
109	184	2430	GH	15	5	1	Brown	2.5YR4/6	2	Yellow-Red

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
110	185	2430	GH	15	5	1	Brown	2.5YR5/8	2	Yellow-Red
111	186	2430	GH	15	5	1	Brown	5YR4/6	2	Yellow-Red
112	187	2430	GH	15	5	1	Brown	2.5YR4/8	2	Yellow-Red
113	188	2430	GH	15	5	1	Brown	2.5YR5/8	2	Yellow-Red
114	189	2430	GH	15	5	1	Brown	2.5YR4/8	2	Yellow-Red
115	190	2430	GH	15	5	1	Brown	5YR4/6	2	Yellow-Red
116	191	2430	GH	15	5	1	Brown	5YR4/6	2	Yellow-Red
117	192	2430	GH	15	5	1	Brown	2.5YR5/8	2	Yellow-Red
118	193	2430	GH	15	5	1	Brown	2.5YR5/8	2	Yellow-Red
119	194	2430	GH	15	5	1	Brown	2.5YR4/8	2	Yellow-Red
120	195	2430	GH	15	5	1	Brown		2	Yellow-Red
121	196	2471	GH	17	4	1	Brown	2.5YR4/8	2	Yellow-Red
122	197	2471	GH	17	4	1	Brown	2.5YR4/8	2	Yellow-Red
123	198	2471	GH	17	4	1	Brown	2.5YR5/8	2	Yellow-Red
124	199	2471	GH	17	4	1	Brown	2.5YR5/8	2	Yellow-Red
125	200	2471	GH	17	4	1	Brown	5YR4/8	2	Yellow-Red
126	201	2045	GH	12	5	1	Brown	5YR5/8	2	Yellow-Red
127	202	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
128	203	2045	GH	12	5	1	Brown	2.5YR4/8	2	Yellow-Red
129	204	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
130	205	2045	GH	12	5	1	Brown	5YR5/8	2	Yellow-Red
131	206	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
132	207	2045	GH	12	5	1	Brown	5YR4/6	2	Yellow-Red
133	208	2045	GH	12	5	1	Brown	5YR4/6	2	Yellow-Red
134	209	2045	GH	12	5	1	Brown	5YR5/6	2	Yellow-Red
135	210	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
136	211	2045	GH	12	5	1	Brown	5YR4/6	2	Yellow-Red
137	212	2045	GH	12	5	1	Brown	2.5YR4/8	2	Yellow-Red
138	213	2045	GH	12	5	1	Brown	5YR5/6	2	Yellow-Red
139	214	2045	GH	12	5	1	Brown	5YR5/6	2	Yellow-Red
140	215	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
141	216	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
142	217	2045	GH	12	5	1	Brown	2.5YR5/8	2	Yellow-Red
143	218	2045	GH	12	5	1	Brown	5YR5/8	2	Yellow-Red
144	219	2045	GH	12	5	1	Brown	2.5YR5/6	2	Yellow-Red
145	220	1428	GH	6	2	7	Brown	10YR8/2	2	Yellow-Red
146	221	1428	GH	6	2	7	Brown	5YR5/6	2	Yellow-Red

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
147	222	1428	GH	6	2	7	Brown	2.5YR4/8	2	Yellow-Red
148	223	1428	GH	6	2	7	Brown	2.5YR4/8	2	Yellow-Red
149	224	1428	GH	6	2	7	Brown	2.5YR5/6	2	Yellow-Red
150	225	1428	GH	6	2	7	Brown	5YR4/6	2	Yellow-Red
151	226	1428	GH	6	2	7	Brown	5YR4/6	2	Yellow-Red
152	227	1428	GH	6	2	7	Brown	5YR4/6	2	Yellow-Red
153	228	1428	GH	6	2	7	Brown	2.5YR5/8	2	Yellow-Red
154	229	1428	GH	6	2	7	Brown	5YR5/8	2	Yellow-Red
155	230	1428	GH	6	2	7	Brown	5YR4/6	2	Yellow-Red
156	231	1428	GH	6	2	7	Brown	5YR5/8	2	Yellow-Red
157	232	1428	GH	6	2	7	Brown	2.5YR5/6	2	Yellow-Red
158	233	1428	GH	6	2	7	Brown	2.5YR5/8	2	Yellow-Red
159	234	1428	GH	6	2	7	Brown	2.5YR4/8	2	Yellow-Red
160	235	1428	GH	6	2	7	Brown	2.5YR4/8	2	Yellow-Red
161	236	1428	GH	6	2	7	Brown	2.5YR5/8	2	Yellow-Red
162	237	1428	GH	6	2	7	Brown	2.5YR4/8	2	Yellow-Red
163	238	1428	GH	6	2	7	Brown	2.5YR5/8	3	Buff
164	239	1428	GH	6	2	7	Brown	5YR5/8	2	Yellow-Red
165	1	2607	GH	16	9	1	Gray	10YR8/2	2	Yellow-Red
166	2	2607	GH	16	9	1	Gray	7.5YR8/4	2	Yellow-Red
167	3	2607	GH	16	9	1	Gray	7.5YR7/4	2	Yellow-Red
168	4	2607	GH	16	9	1	Gray	7.5YR7/4	2	Yellow-Red
169	5	2607	GH	16	9	1	Gray	7.5YR8/3	2	Yellow-Red
170	6	2607	GH	16	9	1	Gray	7.5YR8/2	2	Yellow-Red
171	7	2607	GH	16	9	1	Gray	7.5YR7/4	2	Yellow-Red
172	8	2607	GH	16	9	1	Gray	10YR8/3	2	Yellow-Red
173	9	2607	GH	16	9	1	Gray	10YR8/3	3	Buff
174	10	2607	GH	16	9	1	Gray	7.5YR7/4	3	Buff
175	11	2607	GH	16	9	1	Gray	10YR8/3	3	Buff
176	12	2607	GH	16	9	1	Gray	5YR7/6	3	Buff
177	13	2607	GH	16	9	1	Gray	7.5YR7/6	3	Buff
178	14	2607	GH	16	9	1	Gray	7.5YR8/4	3	Buff
179	15	2607	GH	16	9	1	Gray	10YR8/2	3	Buff
180	16	2588	GH	16	8	1	Gray	10YR8/2	3	Buff
181	17	2588	GH	16	8	1	Gray	7.5YR8/3	3	Buff
182	18	2588	GH	16	8	1	Gray	7.5YR8/4	3	Buff
183	19	2588	GH	16	8	1	Gray	10YR8/3	3	Buff

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
184	20	2588	GH	16	8	1	Gray	7.5YR7/4	3	Buff
185	21	2588	GH	16	8	1	Gray	7.5YR8/3	3	Buff
186	22	2588	GH	16	8	1	Gray	10YR8/3	3	Buff
187	23	2588	GH	16	8	1	Gray	7.5YR8/3	3	Buff
188	24	2588	GH	16	8	1	Gray	7.5YR8/3	3	Buff
189	25	2588	GH	16	8	1	Gray	10YR7/4	3	Buff
190	26	2588	GH	16	8	1	Gray	7.5YR7/6	3	Buff
191	27	2588	GH	16	8	1	Gray	5YR7/8	3	Buff
192	28	2588	GH	16	8	1	Gray	10YR8/3	3	Buff
193	29	2588	GH	16	8	1	Gray	7.5YR8/3	3	Buff
194	30	2588	GH	16	8	1	Gray	7.5YR7/6	3	Buff
195	31	1981	GH	15	1	1	Gray	7.5YR8/4	3	Buff
196	32	1981	GH	15	1	1	Gray	10YR7/4	3	Buff
197	33	1981	GH	15	1	1	Gray	7.5YR8/3	3	Buff
198	34	1981	GH	15	1	1	Gray	7.5YR8/2	3	Buff
199	35	1981	GH	15	1	1	Gray	10YR8/2	3	Buff
200	36	1981	GH	15	1	1	Gray	7.5YR8/2	3	Buff
201	37	1981	GH	15	1	1	Gray	7.5YR8/2	3	Buff
202	38	1981	GH	15	1	1	Gray	7.5YR7/6	3	Buff
203	39	1981	GH	15	1	1	Gray	7.5YR8/3	3	Buff
204	40	1981	GH	15	1	1	Gray	10YR8/2	3	Buff
205	41	1981	GH	15	1	1	Gray	7.5YR8/4	3	Buff
206	42	1981	GH	15	1	1	Gray	7.5YR8/3	3	Buff
207	43	1981	GH	15	1	1	Gray	7.5YR7/6	3	Buff
208	44	1981	GH	15	1	1	Gray	10YR8/2	3	Buff
209	45	1981	GH	15	1	1	Gray	10YR8/2	3	Buff
210	46	1738	M11	2	1	1	Gray	7.5YR8/4	3	Buff
211	47	1738	M11	2	1	1	Gray	10YR8/2	3	Buff
212	48	1738	M11	2	1	1	Gray	10YR8/3	3	Buff
213	49	1738	M11	2	1	1	Gray	7.5YR8/2	3	Buff
214	50	1738	M11	2	1	1	Gray	10YR8/3	3	Buff
215	51	1738	M11	2	1	1	Gray	10YR8/2	3	Buff
216	52	1738	M11	2	1	1	Gray	10YR8/3	3	Buff
217	53	1738	M11	2	1	1	Gray	7.5YR8/4	3	Buff
218	54	1738	M11	2	1	1	Gray	10YR8/3	3	Buff
219	55	1738	M11	2	1	1	Gray	10YR8/3	3	Buff
220	56	1775	M11	1	2	1	Gray	10YR8/2	3	Buff

#	ID#	Spec#	Area	Unit	Level	Locus	Ware	Munsell	Group	Color
221	57	1775	M11	1	2	1	Gray	7.5YR7/4	3	Buff
222	58	1775	M11	1	2	1	Gray	7.5YR7/6	3	Buff
223	59	1775	M11	1	2	1	Gray	10YR8/2	3	Buff
224	60	1775	M11	1	2	1	Gray	5YR5/6	3	Buff
225	61	1779	M6	4	2	1	Gray	7.5YR8/3	3	Buff
226	62	1779	M6	4	2	1	Gray	10YR8/2	3	Buff
227	63	1779	M6	4	2	1	Gray	10YR8/3	3	Buff
228	64	1779	M6	4	2	1	Gray	10YR8/1	3	Buff
229	65	1779	M6	4	2	1	Gray	10YR8/4	3	Buff
230	66	1801	M6	2	2	1	Gray	7.5YR8/3	3	Buff
231	67	1801	M6	2	2	1	Gray	10YR8/2	3	Buff
232	68	74	M15	2	2	1	Gray	10YR8/3	3	Buff
233	69	74	M15	2	2	1	Gray	7.5YR7/6	3	Buff
234	70	74	M15	2	2	1	Gray	10YR8/2	3	Buff
235	71	74	M15	2	2	1	Gray	10YR8/3	3	Buff
236	72	74	M15	2	2	1	Gray	10YR8/4	3	Buff
237	73	74	M15	2	2	1	Gray	10YR7/4	3	Buff
238	74	916	M13	5	1	1	Gray	10YR8/3	3	Buff
239	75	916	M13	5	1	1	Gray	7.5YR8/3		

APPENDIX H: Apparent Porosity Data, Cox Ranch Pueblo

(Sp=Spec#, Ar=Area, Un=Unit, Le=Level, Lo=Locus, Wr=Ware, Por=Unrefired Apparent Porosity, R Por=Refired Apparent Porosity)

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
1	665	M1	2	3	1	BR	11.6	21.2
2	665	M1	2	3	1	BR	18.7	27.2
3	696	M1	2	6	1	BR	19.8	26.2
4	677	M1	3	2	1	BR	18.7	20.3
6	665	M1	2	3	1	BR	16.2	11.0
7	672	M1	2	5	1	BR	18.3	17.7
8	677	M1	3	2	1	BR	17.3	18.1
9	686	M1	3	3	1	BR	18.5	20.4
10	1332	M1	4	5	1	BR	17.7	18.9
11	1332	M1	4	5	1	BR	18.1	15.7
12	1401	M1	5	2	1	BR	18.4	23.7
13	637	M1	2	2	1	BR	16.0	20.2
14	672	M1	2	5	1	BR	18.5	21.6
15	1327	M1	4	4	1	BR	19.3	23.8
16	1327	M1	4	4	1	BR	20.7	25.5
17	1337	M1	5	1	1	BR	21.0	21.5
18	146	M3	2	1	1	BR	20.2	22.7
19	166	M3	2	2	1	BR	18.8	23.4
20	365	M3	2	8	1	BR	20.3	23.4
21	201	M3	3	2	1	BR	20.0	20.0
22	230	M3	3	3	1	BR	15.8	16.7
23	255	M3	4	0	1	BR	14.5	18.9
24	335	M3	4	1	1	BR	16.4	21.6
25	335	M3	4	1	1	BR	17.8	21.6
26	378	M3	4	2	1	BR	14.8	18.8
27	403	M3	4	3	1	BR	17.2	20.4
28	437	M3	5	2	1	BR	17.0	20.5
29	214	M3	2	4	1	BR	17.6	20.7
30	230	M3	3	3	1	BR	17.6	17.9
31	237	M3	1	2	1	BR	21.0	21.6
32	146	M3	2	1	1	BR	16.7	19.1
33	166	M3	2	2	1	BR	16.1	17.8
34	157	M3	3	1	1	BR	13.1	14.3
35	201	M3	3	2	1	BR	16.4	19.3
37	335	M3	4	1	1	BR	16.2	22.0
38	378	M3	4	2	1	BR	20.7	22.4
39	403	M3	4	3	1	BR	17.1	20.3
40	403	M3	4	3	1	BR	20.9	22.7
41	431	M3	5	1	1	BR	19.1	20.4
42	146	M3	2	1	1	BR	16.8	16.7
43	157	M3	3	1	1	BR	18.1	19.4
44	378	M3	4	2	1	BR	17.4	19.5
45	894	M7	1	1	1	BR	17.4	19.0
46	930	M7	3	2	1	BR	18.8	20.0
47	959	M7	3	3	1	BR	15.9	19.3
48	894	M7	1	1	1	BR	17.4	22.3
49	870	M7	3	1	1	BR	17.8	17.6
50	930	M7	3	2	1	BR	16.9	17.6
51	959	M7	3	3	1	BR	18.9	20.7
52	982	M7	3	4	1	BR	20.5	19.7
53	1002	M7	3	5	1	BR	19.3	21.1
54	1130	M7	3	8	1	BR	18.2	20.9
55	1205	M7	3	10	1	BR	14.7	17.3
56	922	M7	5	2	1	BR	19.7	21.3
57	967	M7	5	3	1	BR	20.9	22.3
58	930	M7	3	2	1	BR	12.4	18.0
59	1002	M7	3	5	1	BR	15.8	20.0
60	1130	M7	3	8	1	BR	15.3	22.1
61	168	M10	4	1	1	BR	22.5	22.2
63	247	M10	5	3	1	BR	16.4	19.8
64	24	M10	2	1	1	BR	16.1	17.8
65	60	M10	3	1	1	BR	16.1	21.0
66	60	M10	3	1	1	BR	17.2	19.3
67	168	M10	4	1	1	BR	14.9	16.7
68	216	M10	4	2	1	BR	13.5	14.5
69	197	M10	5	2	1	BR	17.6	22.6
70	476	M10	6	1	1	BR	19.4	24.0
71	476	M10	6	1	1	BR	17.8	19.1
72	24	M10	2	1	1	BR	17.4	22.9
73	168	M10	4	1	1	BR	15.8	17.9
74	197	M10	5	2	1	BR	19.1	24.3
76	476	M10	6	1	1	BR	16.1	17.5
77	476	M10	6	1	1	BR	15.0	20.2
78	491	M10	6	2	1	BR	15.3	18.3
79	28	M12	1	1	1	BR	17.9	19.4
80	77	M12	1	2	1	BR	19.6	18.9
81	275	M12	1	3	1	BR	14.9	12.5
82	564	M12	4	1	1	BR	17.3	19.8
83	654	M12	4	3	1	BR	17.6	21.2
84	374	M12	1	6	1	BR	23.4	24.6
85	51	M12	2	1	1	BR	16.3	22.6
86	99	M12	2	2	1	BR	15.8	19.4
87	279	M12	2	3	1	BR	18.2	21.6
90	28	M12	1	1	1	BR	17.9	17.2
91	77	M12	1	2	1	BR	15.9	20.5
92	77	M12	1	2	1	BR	20.7	21.7
93	275	M12	1	3	1	BR	19.3	18.9
94	306	M12	1	4	1	BR	17.1	16.7
95	325	M12	1	5	1	BR	17.1	16.2

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
96	374	M12	1	6	1	BR	20.0	19.6
97	16	M12	1	8	1	BR	20.0	21.3
98	16	M12	1	8	1	BR	23.7	24.7
100	51	M12	2	1	1	BR	17.1	19.4
345	469	GH	4	5	1	BR	17.2	18.0
346	1375	GH	9	2	1	BR	16.3	20.4
347	1413	GH	9	3	1	BR	22.6	18.8
348	1274	GH	10	1	1	BR	17.5	18.5
349	1962	GH	12	4	1	BR	18.0	21.8
350	2045	GH	12	5	1	BR	17.3	20.5
351	2110	GH	12	6	1	BR	21.3	21.7
352	2215	GH	12	8	1	BR	18.2	21.1
353	2179	GH	15	3	1	BR	19.2	20.5
354	2179	GH	15	3	1	BR	14.5	22.5
355	2519	GH	16	6	1	BR	17.4	20.2
356	469	GH	4	1	1	BR	16.0	18.7
357	469	GH	4	1	1	BR	20.8	25.3
358	469	GH	4	1	1	BR	18.2	19.6
359	529	GH	4	3	1	BR	18.8	22.1
360	529	GH	4	3	1	BR	18.3	19.2
361	2071	GH	15	2	1	BR	20.3	20.4
362	2179	GH	15	3	1	BR	19.6	21.2
363	2430	GH	15	5	1	BR	15.5	18.4
364	2430	GH	15	5	1	BR	17.8	21.8
365	469	GH	4	1	1	BR	17.9	18.8
366	469	GH	4	1	1	BR	18.4	19.4
367	529	GH	4	3	1	BR	19.2	18.4
368	1413	GH	9	3	1	BR	16.7	18.8
369	2215	GH	12	8	1	BR	15.8	22.3
370	2071	GH	15	2	1	BR	15.1	20.0
371	2179	GH	15	3	1	BR	17.4	17.7
372	2430	GH	15	5	1	BR	17.3	16.4
5	686	M1	3	3	1	BR	20.5	20.6
36	201	M3	3	2	1	BR	21.9	21.6
62	143	M10	5	1	1	BR	15.1	19.5
88	306	M12	1	4	1	BR	17.3	18.8
89	272	M12	3	3	1	BR	15.4	21.3
99	51	M12	2	1	1	BR	16.7	16.9
101	99	M12	2	22	1	BR	16.0	16.2
102	279	M12	2	3	1	BR	23.8	23.1
103	279	M12	2	3	1	BR	20.0	18.8
104	43	M12	3	1	1	BR	18.1	18.6
105	91	M12	3	2	1	BR	18.7	22.6
106	272	M12	3	3	1	BR	22.2	24.4
108	623	M12	4	2	1	BR	23.1	26.2
109	28	M12	1	1	1	BR	17.3	21.6
110	275	M12	1	3	1	BR	18.6	22.4

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
111	306	M12	1	4	1	BR	18.4	25.4
112	306	M12	1	4	1	BR	20.2	21.2
113	374	M12	1	6	1	BR	19.5	20.9
114	51	M12	2	1	1	BR	19.1	22.6
115	279	M12	2	3	1	BR	16.8	19.1
116	564	M12	4	1	1	BR	16.7	18.6
117	654	M12	4	3	1	BR	15.4	19.4
118	82	M15	1	3	1	BR	16.2	21.0
119	82	M15	1	3	1	BR	20.3	21.9
120	126	M15	1	4	1	BR	20.0	22.6
121	126	M15	1	4	1	BR	19.0	17.7
122	150	M15	1	6	1	BR	14.6	19.3
123	177	M15	1	7	1	BR	14.0	21.3
124	208	M15	1	8	1	BR	17.9	21.3
125	36	M15	2	1	1	BR	14.7	17.2
126	36	M15	2	1	1	BR	15.5	19.0
127	74	M15	2	2	1	BR	12.8	17.5
128	96	M15	2	3	1	BR	19.2	22.6
129	70	M15	1	2	1	BR	16.3	19.4
130	208	M15	1	8	1	BR	18.6	17.6
131	221	M15	1	1	1	BR	19.3	18.8
132	82	M15	1	3	1	BR	18.3	16.1
133	126	M15	1	4	1	BR	17.6	17.5
134	134	M15	1	5	1	BR	17.4	21.5
135	150	M15	1	6	1	BR	16.4	17.8
136	177	M15	1	7	1	BR	15.0	18.8
137	177	M15	1	7	1	BR	16.3	22.2
138	208	M15	1	8	1	BR	15.7	15.7
139	208	M15	1	8	1	BR	15.7	19.6
140	226	M15	1	9	1	BR	16.8	16.0
141	126	M15	1	4	1	BR	15.9	18.4
143	177	M15	1	7	1	BR	13.9	21.8
144	177	M15	1	7	1	BR	19.4	21.2
145	1277	GH	9	1	1	BR	18.4	20.7
147	1375	GH	9	2	1	BR	15.0	21.1
148	1413	GH	9	3	1	BR	18.3	30.8
149	1380	GH	10	2	1	BR	16.7	19.8
150	1387	GH	10	3	1	BR	14.5	17.3
151	2215	GH	12	8	1	BR	15.3	15.6
152	2179	GH	15	3	1	BR	17.7	22.4
153	2179	GH	15	3	1	BR	16.9	21.5
155	2395	GH	17	2	1	BR	17.7	22.4
156	2395	GH	17	2	1	BR	16.2	20.5
157	2471	GH	17	4	1	BR	18.4	18.8
158	2430	GH	15	5	1	BR	17.8	19.0
159	1375	GH	9	2	1	BR	20.0	25.2
160	1413	GH	9	3	1	BR	16.4	19.6

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
161	1274	GH	10	1	1	BR	16.7	22.1
163	1380	GH	10	2	1	BR	17.5	17.6
164	1981	GH	15	1	1	BR	20.0	18.2
165	2179	GH	15	3	1	BR	15.7	18.2
166	2519	GH	16	6	1	BR	16.7	19.3
167	2471	GH	17	4	1	BR	22.8	24.0
168	2562	GH	17	5	1	BR	22.2	20.7
169	1962	GH	12	4	1	BR	18.3	23.7
170	2162	GH	12	7	1	BR	17.0	21.0
171	1981	GH	15	1	1	BR	18.9	21.6
172	1981	GH	15	1	1	BR	18.8	24.7
173	2215	GH	12	8	1	BR	20.3	23.6
174	1277	GH	9	1	1	BR	18.3	22.1
175	1277	GH	9	1	1	BR	16.9	20.5
176	1375	GH	9	2	1	BR	18.4	18.1
177	1413	GH	9	3	1	BR	25.4	20.5
178	1413	GH	9	3	1	BR	14.4	19.0
179	1504	GH	9	4	1	BR	19.7	19.0
180	1274	GH	10	1	1	BR	18.5	20.0
181	1380	GH	10	2	1	BR	17.6	16.5
182	1962	GH	12	4	1	BR	19.6	24.3
183	2045	GH	12	5	1	BR	25.7	24.5
184	2110	GH	12	6	1	BR	18.3	20.9
185	2162	GH	12	7	1	BR	14.7	21.6
187	1981	GH	15	1	1	BR	17.6	20.5
188	2071	GH	15	2	1	BR	20.0	20.0
189	2179	GH	15	3	1	BR	18.6	18.1
190	2430	GH	15	5	1	BR	17.9	18.9
191	2519	GH	16	6	1	BR	16.2	-53.1
192	2471	GH	17	4	1	BR	17.5	-7.1
193	2562	GH	17	5	1	BR	21.3	21.9
194	2597	GH	17	6	1	BR	18.4	43.0
195	529	GH	4	3	1	BR	19.0	-7.6
196	1277	GH	9	1	1	BR	18.2	-28.9
197	1413	GH	9	3	1	BR	17.8	20.9
198	1274	GH	10	1	1	BR	21.8	20.3
199	2071	GH	15	2	1	BR	16.3	23.3
200	2179	GH	15	3	1	BR	20.8	21.4
201	2519	GH	16	6	1	BR	15.3	19.5
202	2597	GH	17	6	1	BR	15.0	21.9
203	182	M1	1	1	1	BR	17.0	15.9
204	603	M1	2	1	1	BR	8.6	18.3
206	637	M1	2	2	1	BR	18.4	20.4
207	1177	M1	4	1	1	BR	16.0	19.6
208	1222	M1	4	3	1	BR	18.6	19.6
209	1337	M1	5	1	1	BR	19.2	20.8
210	1337	M1	5	1	1	BR	18.8	23.3

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
211	1401	M1	5	2	1	BR	14.5	20.0
212	1401	M1	5	2	1	BR	14.8	21.4
213	182	M1	1	1	1	BR	21.1	22.6
214	662	M1	3	1	1	BR	20.1	21.7
215	1209	M1	4	2	1	BR	16.6	19.8
216	1222	M1	4	3	1	BR	16.7	23.1
217	1327	M1	4	4	1	BR	21.1	22.6
218	182	M1	1	1	1	BR	18.8	17.8
219	603	M1	2	1	1	BR	19.5	20.9
220	672	M1	2	5	1	BR	18.9	22.0
221	677	M1	3	2	1	BR	19.4	22.2
224	146	M3	2	1	1	BR	21.6	23.0
225	146	M3	2	1	1	BR	16.6	19.7
226	157	M3	3	1	1	BR	14.2	18.1
227	378	M3	4	2	1	BR	20.0	21.2
228	378	M3	4	2	1	BR	16.0	20.0
229	403	M3	4	3	1	BR	19.1	21.5
230	403	M3	4	3	1	BR	17.6	18.4
231	446	M3	4	5	1	BR	16.7	21.1
232	299	M3	1	3	1	BR	18.8	21.1
233	157	M3	3	1	1	BR	17.9	21.0
234	424	M3	4	4	1	BR	19.0	22.3
235	431	M3	5	1	1	BR	17.7	19.6
236	237	M3	1	2	1	BR	16.3	17.6
237	237	M3	1	2	1	BR	17.1	19.8
238	146	M3	2	1	1	BR	21.4	21.4
239	157	M3	3	1	1	BR	15.6	19.5
240	335	M3	4	1	1	BR	17.2	24.1
241	403	M3	4	3	1	BR	17.6	17.9
242	403	M3	4	3	1	BR	25.6	26.7
243	894	M7	1	1	1	BR	19.5	22.1
244	870	M7	3	1	1	BR	16.8	17.2
245	930	M7	3	2	1	BR	17.1	19.1
246	959	M7	3	3	1	BR	22.0	21.9
248	982	M7	3	4	1	BR	16.7	20.0
249	982	M7	3	4	1	BR	15.9	18.9
250	1002	M7	3	5	1	BR	19.7	20.7
251	1002	M7	3	5	1	BR	15.4	19.9
252	922	M7	5	2	1	BR	19.3	19.6
253	967	M7	5	3	1	BR	17.8	21.9
254	870	M7	3	1	1	BR	17.0	20.4
255	1205	M7	3	10	1	BR	17.5	18.9
256	894	M7	1	1	1	BR	16.0	25.3
257	894	M7	1	1	1	BR	15.6	19.4
258	870	M7	3	1	1	BR	16.4	20.0
259	870	M7	3	1	1	BR	17.1	18.8
260	959	M7	3	3	1	BR	17.4	18.9

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
261	922	M7	5	2	1	BR	14.3	17.5
262	922	M7	5	2	1	BR	17.5	18.6
263	24	M10	2	1	1	BR	20.0	24.6
264	60	M10	3	1	1	BR	19.7	21.5
265	168	M10	4	1	1	BR	17.3	20.4
266	143	M10	5	1	1	BR	16.2	22.9
267	476	M10	6	1	1	BR	11.3	20.8
268	476	M10	6	1	1	BR	20.2	21.2
269	38	M10	1	1	1	BR	15.8	22.6
270	102	M10	4	3	1	BR	17.9	20.0
271	143	M10	5	1	1	BR	20.9	21.6
272	168	M10	4	1	1	BR	19.4	21.1
273	168	M10	4	1	1	BR	17.6	22.6
274	143	M10	5	1	1	BR	14.8	36.7
275	247	M10	5	3	1	BR	20.0	20.8
276	396	M12	1	7	1	BR	17.7	22.6
277	51	M12	2	1	1	BR	14.2	19.4
278	275	M12	1	3	1	BR	15.0	21.3
279	306	M12	1	4	1	BR	16.1	17.6
280	325	M12	1	5	1	BR	20.0	19.7
281	51	M12	2	1	1	BR	18.7	21.9
282	279	M12	2	3	1	BR	21.4	21.4
283	279	M12	2	3	1	BR	19.4	19.5
284	623	M12	4	2	1	BR	12.9	21.6
285	77	M12	1	2	1	BR	14.3	16.8
286	16	M12	1	8	1	BR	18.5	18.3
287	51	M12	2	1	1	BR	18.2	20.0
288	654	M12	4	3	1	BR	18.0	22.4
289	28	M12	1	1	1	BR	21.2	22.1
290	28	M12	1	1	1	BR	17.9	19.8
291	28	M12	1	1	1	BR	16.7	18.3
292	77	M12	1	2	1	BR	16.5	20.9
293	99	M12	2	2	1	BR	17.7	22.4
294	43	M12	3	1	1	BR	18.1	18.4
295	91	M12	3	2	1	BR	17.4	18.2
296	272	M12	3	3	1	BR	14.3	19.2
297	564	M12	4	1	1	BR	18.8	23.0
298	17	M12	1	2	1	BR	20.3	24.7
299	306	M12	1	4	1	BR	16.2	19.3
300	325	M12	1	5	1	BR	14.6	20.9
301	51	M12	2	1	1	BR	19.3	20.2
302	99	M12	2	2	1	BR	20.2	21.1
303	43	M12	3	1	1	BR	18.3	22.5
304	91	M12	3	2	1	BR	17.3	20.1
305	272	M12	3	3	1	BR	19.9	21.7
306	564	M12	4	1	1	BR	21.2	21.4
307	623	M12	4	2	1	BR	18.6	13.3

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
308	21	M15	1	1	1	BR	21.0	23.1
309	21	M15	1	1	1	BR	16.7	17.1
310	82	M15	1	3	1	BR	20.5	21.2
311	126	M15	1	4	1	BR	17.3	17.7
312	150	M15	1	6	1	BR	20.5	21.6
313	177	M15	1	7	1	BR	15.2	18.4
314	177	M15	1	7	1	BR	17.0	17.8
315	134	M15	1	15	1	BR	17.3	8.1
316	21	M15	1	1	1	BR	15.5	18.7
317	74	M15	2	2	1	BR	18.8	20.9
318	126	M15	1	4	1	BR	17.2	20.2
319	134	M15	1	5	1	BR	17.7	18.4
321	226	M15	1	9	1	BR	19.7	20.3
322	226	M15	1	9	1	BR	18.5	20.5
323	36	M15	2	1	1	BR	16.8	22.2
324	96	M15	2	3	1	BR	52.4	20.6
325	250	M15	1	10	1	BR	19.7	16.7
326	21	M15	1	1	1	BR	17.6	19.0
327	70	M15	1	2	1	BR	16.9	20.0
328	82	M15	1	3	1	BR	16.6	21.5
329	134	M15	1	5	1	BR	16.5	18.5
330	150	M15	1	6	1	BR	20.2	19.6
331	150	M15	1	6	1	BR	20.5	22.1
332	208	M15	1	8	1	BR	18.3	20.4
333	1962	GH	12	4	1	BR	19.4	22.8
334	2179	GH	15	3	1	BR	19.0	17.7
335	587	GH	3	6	1	BR	15.3	20.0
336	587	GH	3	6	1	BR	15.8	20.4
337	587	GH	3	6	1	BR	15.4	22.4
338	587	GH	3	6	1	BR	14.7	18.8
339	469	GH	4	1	1	BR	18.8	26.2
340	469	GH	4	1	1	BR	14.1	17.1
341	243	GH	4	3	1	BR	25.0	19.1
342	243	GH	4	3	1	BR	18.1	22.2
343	469	GH	4	5	1	BR	15.3	16.1
344	469	GH	4	5	1	BR	17.6	20.0
76	2562	GH	17	5	1	BR	21.7	21.7
77	2562	GH	17	5	1	BR	23.5	21.6
78	2562	GH	17	5	1	BR	22.5	24.6
79	2562	GH	17	5	1	BR	21.7	24.6
80	2562	GH	17	5	1	BR	21.3	22.4
81	2562	GH	17	5	1	BR	22.5	24.3
82	2562	GH	17	5	1	BR	24.0	23.4
83	74	M15	2	2	1	BR	20.2	20.6
84	74	M15	2	2	1	BR	20.3	21.4
85	74	M15	2	2	1	BR	20.0	21.3
86	74	M15	2	2	1	BR	21.5	23.0

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
87	74	M15	2	2	1	BR	21.1	21.8
88	74	M15	2	2	1	BR	19.4	22.6
89	74	M15	2	2	1	BR	20.5	20.0
90	74	M15	2	2	1	BR	23.0	21.1
91	74	M15	2	2	1	BR	21.6	20.8
92	74	M15	2	2	1	BR	21.2	20.0
93	74	M15	2	2	1	BR	22.0	21.8
94	916	M13	5	1	1	BR	16.7	23.1
95	916	M13	5	1	1	BR	23.3	22.5
96	916	M13	5	1	1	BR	22.7	25.0
97	916	M13	5	1	1	BR	21.2	23.3
98	916	M13	5	1	1	BR	25.0	22.2
99	916	M13	5	1	1	BR	22.6	20.4
100	916	M13	5	1	1	BR	20.6	21.7
101	916	M13	5	1	1	BR	19.0	21.4
102	916	M13	5	1	1	BR	23.4	25.7
103	916	M13	5	1	1	BR	24.1	25.9
104	916	M13	5	1	1	BR	18.8	20.0
105	1801	M6	2	2	1	BR	19.3	22.6
106	1801	M6	2	2	1	BR	20.3	23.2
107	1801	M6	2	2	1	BR	20.0	22.0
108	1801	M6	2	2	1	BR	21.3	21.7
109	1801	M6	2	2	1	BR	24.3	24.6
110	1801	M6	2	2	1	BR	22.9	23.4
111	1801	M6	2	2	1	BR	19.7	19.4
113	1801	M6	2	2	1	BR	25.2	23.7
114	1801	M6	2	2	1	BR	20.6	23.8
115	1779	M6	4	2	1	BR	23.2	22.4
116	1779	M6	4	2	1	BR	20.6	25.0
117	1779	M6	4	2	1	BR	21.6	23.0
118	1981	GH	15	1	1	BR	22.4	20.7
119	1981	GH	15	1	1	BR	23.6	23.9
120	1981	GH	15	1	1	BR	18.2	22.5
121	1981	GH	15	1	1	BR	21.3	23.4
122	1981	GH	15	1	1	BR	20.4	22.5
123	1981	GH	15	1	1	BR	22.1	22.9
124	1981	GH	15	1	1	BR	19.7	23.5
125	1981	GH	15	1	1	BR	19.1	20.8
126	1981	GH	15	1	1	BR	18.7	18.8
127	1981	GH	15	1	1	BR	20.3	22.5
128	1981	GH	15	1	1	BR	21.9	22.1
129	1981	GH	15	1	1	BR	21.8	21.7
130	1981	GH	15	1	1	BR	18.8	21.9
131	1981	GH	15	1	1	BR	23.9	20.0
132	1981	GH	15	1	1	BR	20.3	21.3
133	1981	GH	15	1	1	BR	19.1	20.7
134	1981	GH	15	1	1	BR	21.3	25.6
135	1981	GH	15	1	1	BR	21.2	22.2
136	1981	GH	15	1	1	BR	21.4	21.3
137	1981	GH	15	1	1	BR	16.4	19.7
138	1981	GH	15	1	1	BR	25.0	25.6
139	1981	GH	15	1	1	BR	22.1	21.9
140	1981	GH	15	1	1	BR	24.0	24.7
141	1981	GH	15	1	1	BR	21.6	25.5
142	1981	GH	15	1	1	BR	21.7	23.7
143	1981	GH	15	1	1	BR	21.9	21.7
144	1981	GH	15	1	1	BR	24.6	23.6
145	1981	GH	15	1	1	BR	19.3	22.2
146	1981	GH	15	1	1	BR	16.5	19.8
147	1981	GH	15	1	1	BR	22.0	23.6
148	2588	GH	16	8	1	BR	20.8	23.9
149	2588	GH	16	8	1	BR	21.4	22.7
150	2588	GH	16	8	1	BR	21.6	23.5
151	2588	GH	16	8	1	BR	24.6	25.0
152	2588	GH	16	8	1	BR	18.2	20.5
153	2588	GH	16	8	1	BR	22.5	23.7
154	2588	GH	16	8	1	BR	20.0	20.2
155	2588	GH	16	8	1	BR	24.7	25.9
156	2588	GH	16	8	1	BR	26.0	24.1
157	2588	GH	16	8	1	BR	23.6	25.9
158	2588	GH	16	8	1	BR	22.4	23.6
159	2588	GH	16	8	1	BR	24.6	27.0
160	2588	GH	16	8	1	BR	25.5	24.8
161	2607	GH	16	9	1	BR	21.7	22.1
162	2607	GH	16	9	1	BR	20.6	22.3
163	2607	GH	16	9	1	BR	24.3	26.2
164	2607	GH	16	9	1	BR	18.9	21.6
165	2607	GH	16	9	1	BR	19.5	19.5
166	2607	GH	16	9	1	BR	19.7	23.1
167	2607	GH	16	9	1	BR	21.6	23.8
168	2607	GH	16	9	1	BR	20.7	20.8
169	2607	GH	16	9	1	BR	25.6	25.3
170	2607	GH	16	9	1	BR	21.6	23.4
171	2607	GH	16	9	1	BR	21.4	22.6
172	1775	M11	1	2	1	BR	20.3	20.0
173	1775	M11	1	2	1	BR	24.7	25.8
174	1775	M11	1	2	1	BR	21.7	23.3
175	1775	M11	1	2	1	BR	22.3	22.9
176	1775	M11	1	2	1	BR	25.6	25.0
177	1775	M11	1	2	1	BR	20.6	20.3
178	1775	M11	1	2	1	BR	22.9	23.7
179	1775	M11	1	2	1	BR	19.3	22.4
180	1775	M11	1	2	1	BR	23.8	25.4
181	1775	M11	1	2	1	BR	19.6	22.0

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
182	2430	GH	15	5	1	BR	23.9	23.9
183	2430	GH	15	5	1	BR	21.1	22.9
184	2430	GH	15	5	1	BR	20.5	20.6
185	2430	GH	15	5	1	BR	16.4	18.8
186	2430	GH	15	5	1	BR	19.6	20.0
187	2430	GH	15	5	1	BR	18.9	20.8
188	2430	GH	15	5	1	BR	28.6	28.6
189	2430	GH	15	5	1	BR	18.9	22.0
190	2430	GH	15	5	1	BR	20.0	24.2
191	2430	GH	15	5	1	BR	19.8	23.3
192	2430	GH	15	5	1	BR	17.6	19.7
193	2430	GH	15	5	1	BR	20.6	20.9
194	2430	GH	15	5	1	BR	20.5	21.6
196	2471	GH	17	4	1	BR	22.0	21.8
197	2471	GH	17	4	1	BR	23.6	21.8
198	2471	GH	17	4	1	BR	21.9	20.8
199	2471	GH	17	4	1	BR	21.3	21.3
200	2471	GH	17	4	1	BR	22.4	21.3
201	2045	GH	12	5	1	BR	22.0	25.0
202	2045	GH	12	5	1	BR	20.5	25.7
203	2045	GH	12	5	1	BR	19.8	24.7
204	2045	GH	12	5	1	BR	21.2	24.1
205	2045	GH	12	5	1	BR	20.5	24.4
206	2045	GH	12	5	1	BR	20.4	23.5
207	2045	GH	12	5	1	BR	20.0	24.6
208	2045	GH	12	5	1	BR	21.3	24.2
209	2045	GH	12	5	1	BR	23.6	24.3
210	2045	GH	12	5	1	BR	21.4	20.0
211	2045	GH	12	5	1	BR	21.3	24.1
212	2045	GH	12	5	1	BR	19.7	24.1
213	2045	GH	12	5	1	BR	20.2	23.8
214	2045	GH	12	5	1	BR	18.2	26.0
215	2045	GH	12	5	1	BR	24.1	24.7
216	2045	GH	12	5	1	BR	21.8	24.6
217	2045	GH	12	5	1	BR	21.2	24.4
218	2045	GH	12	5	1	BR	23.2	25.0
219	2045	GH	12	5	1	BR	24.3	23.2
220	1428	GH	6	2	7	BR	19.6	18.5
221	1428	GH	6	2	7	BR	20.3	23.2
222	1428	GH	6	2	7	BR	22.0	22.2
223	1428	GH	6	2	7	BR	21.6	20.8
224	1428	GH	6	2	7	BR	20.0	18.6
225	1428	GH	6	2	7	BR	19.7	21.3
226	1428	GH	6	2	7	BR	21.5	20.6
227	1428	GH	6	2	7	BR	20.5	24.1
228	1428	GH	6	2	7	BR	21.3	21.6
229	1428	GH	6	2	7	BR	20.2	23.0

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
230	1428	GH	6	2	7	BR	21.6	24.0
231	1428	GH	6	2	7	BR	20.4	22.0
232	1428	GH	6	2	7	BR	19.3	20.0
233	1428	GH	6	2	7	BR	7.2	23.1
234	1428	GH	6	2	7	BR	21.6	23.6
235	1428	GH	6	2	7	BR	19.5	25.0
236	1428	GH	6	2	7	BR	15.7	14.9
237	1428	GH	6	2	7	BR	21.8	23.2
238	1428	GH	6	2	7	BR	23.4	23.8
239	1428	GH	6	2	7	BR	20.9	22.2
373	603	GH	2	1	1	GR	24.1	20.5
374	603	GH	2	1	1	GR	21.2	25.4
375	672	M1	2	5	1	GR	20.6	17.3
376	672	M1	2	5	1	GR	23.3	21.9
377	1209	M1	4	2	1	GR	20.0	20.7
378	182	M3	1	1	1	GR	24.4	22.4
379	201	M3	3	2	1	GR	20.9	19.7
380	403	M3	4	3	1	GR	25.6	27.3
381	361	M3	1	4	1	GR	22.1	18.9
382	378	M3	4	2	1	GR	22.1	21.4
383	870	M7	3	1	1	GR	23.5	22.1
384	959	M7	3	3	1	GR	23.1	17.2
385	982	M7	3	4	1	GR	23.8	23.0
386	1002	M7	3	5	1	GR	20.4	22.9
387	1130	M7	3	8	1	GR	23.0	21.6
388	922	M7	5	2	1	GR	23.8	12.8
389	24	M10	2	1	1	GR	28.6	24.1
390	24	M10	2	1	1	GR	26.8	23.0
391	60	M10	3	1	1	GR	20.0	18.1
392	197	M10	5	2	1	GR	21.5	20.2
393	476	M10	6	1	1	GR	23.5	26.8
394	476	M10	6	1	1	GR	17.9	16.5
395	28	M12	1	1	1	GR	23.5	23.9
396	77	M12	1	2	1	GR	23.4	18.4
397	77	M12	1	2	1	GR	23.0	23.3
398	306	M12	1	4	1	GR	19.4	18.3
399	325	M12	1	5	1	GR	27.1	27.8
400	396	M12	1	7	1	GR	20.0	16.4
402	99	M12	2	2	1	GR	25.2	22.0
403	99	M12	2	2	1	GR	20.3	17.5
404	272	M12	3	3	1	GR	22.6	21.7
405	564	M12	4	1	1	GR	20.8	22.6
406	396	M12	1	7	1	GR	21.4	23.3
407	21	M15	1	1	1	GR	27.7	27.5
408	70	M15	1	2	1	GR	23.5	26.7
409	134	M15	1	5	1	GR	20.3	20.2
410	150	M15	1	6	1	GR	23.2	24.0

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
411	150	M15	1	6	1	GR	19.9	20.4
412	177	M15	1	7	1	GR	21.5	22.4
413	96	M15	2	3	1	GR	22.6	22.2
414	177	M15	1	7	1	GR	21.8	21.5
415	208	M15	1	8	1	GR	24.9	27.0
416	82	M15	1	3	1	GR	27.7	28.3
417	126	M15	1	4	1	GR	23.0	25.2
418	469	GH	4	1	1	GR	21.6	21.6
419	469	GH	4	1	1	GR	25.3	59.8
420	529	GH	4	3	1	GR	17.7	17.0
421	529	GH	4	3	1	GR	16.5	18.9
422	529	GH	4	3	1	GR	15.9	20.9
423	529	GH	4	3	1	GR	23.9	25.4
424	248	GH	4	3	1	GR	19.5	20.8
426	246	GH	4	3	1	GR	11.7	12.0
427	529	GH	4	3	1	GR	13.1	15.4
428	539	GH	4	4	1	GR	9.7	14.6
430	539	GH	4	4	1	GR	16.8	17.2
431	469	GH	4	5	1	GR	19.1	20.7
432	2430	GH	15	5	1	GR	20.0	22.7
433	2519	GH	16	6	1	GR	20.0	24.3
434	1380	GH	10	2	1	GR	28.6	26.8
435	2519	GH	16	6	1	GR	26.2	24.5
436	1413	GH	9	3	1	GR	19.9	18.9
437	1413	GH	9	3	1	GR	17.8	19.8
438	2045	GH	12	5	1	GR	24.6	27.0
439	2162	GH	12	7	1	GR	19.5	24.7
442	157	M3	3	1	1	GR	19.2	21.0
443	1002	M7	3	5	1	GR	19.4	21.5
444	1380	GH	10	2	1	GR	16.5	19.1
1	2607	GH	16	9	1	GR	21.4	24.4
2	2607	GH	16	9	1	GR	18.6	22.8
3	2607	GH	16	9	1	GR	24.7	24.7
4	2607	GH	16	9	1	GR	19.6	24.5
5	2607	GH	16	9	1	GR	27.3	25.0
6	2607	GH	16	9	1	GR	24.7	26.7
7	2607	GH	16	9	1	GR	17.1	23.1
8	2607	GH	16	9	1	GR	20.3	21.9
9	2607	GH	16	9	1	GR	21.7	23.3
10	2607	GH	16	9	1	GR	25.8	27.0
11	2607	GH	16	9	1	GR	19.7	25.3
12	2607	GH	16	9	1	GR	19.3	17.6
13	2607	GH	16	9	1	GR	21.4	23.7
14	2607	GH	16	9	1	GR	22.7	23.9
15	2607	GH	16	9	1	GR	23.5	25.3
16	2588	GH	16	8	1	GR	23.1	25.7
17	2588	GH	16	8	1	GR	22.0	23.2

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
18	2588	GH	16	8	1	GR	25.6	25.0
19	2588	GH	16	8	1	GR	17.6	19.8
20	2588	GH	16	8	1	GR	22.0	23.0
21	2588	GH	16	8	1	GR	22.8	20.9
22	2588	GH	16	8	1	GR	22.9	25.8
23	2588	GH	16	8	1	GR	20.3	23.0
24	2588	GH	16	8	1	GR	20.3	25.5
25	2588	GH	16	8	1	GR	32.5	23.6
26	2588	GH	16	8	1	GR	20.3	20.9
27	2588	GH	16	8	1	GR	25.3	21.4
28	2588	GH	16	8	1	GR	24.1	25.6
29	2588	GH	16	8	1	GR	23.3	25.6
30	2588	GH	16	8	1	GR	22.7	23.9
31	1981	GH	15	1	1	GR	26.3	25.4
32	1981	GH	15	1	1	GR	15.5	17.9
33	1981	GH	15	1	1	GR	20.4	20.0
34	1981	GH	15	1	1	GR	19.6	18.2
35	1981	GH	15	1	1	GR	25.0	25.4
36	1981	GH	15	1	1	GR	18.2	23.3
37	1981	GH	15	1	1	GR	21.2	21.2
38	1981	GH	15	1	1	GR	26.6	26.8
39	1981	GH	15	1	1	GR	18.3	24.1
40	1981	GH	15	1	1	GR	19.0	26.0
41	1981	GH	15	1	1	GR	25.7	24.8
42	1981	GH	15	1	1	GR	21.1	20.8
43	1981	GH	15	1	1	GR	20.8	22.0
44	1981	GH	15	1	1	GR	23.0	24.4
45	1981	GH	15	1	1	GR	25.0	25.2
46	1738	M11	2	1	1	GR	25.0	25.3
47	1738	M11	2	1	1	GR	26.5	27.5
48	1738	M11	2	1	1	GR	28.1	28.8
49	1738	M11	2	1	1	GR	25.9	25.9
50	1738	M11	2	1	1	GR	33.3	27.8
51	1738	M11	2	1	1	GR	24.6	25.0
52	1738	M11	2	1	1	GR	25.0	26.1
53	1738	M11	2	1	1	GR	27.5	28.0
54	1738	M11	2	1	1	GR	23.8	24.6
55	1738	M11	2	1	1	GR	25.0	25.8
56	1775	M11	1	2	1	GR	27.3	27.0
57	1775	M11	1	2	1	GR	23.5	28.1
58	1775	M11	1	2	1	GR	23.4	21.7
59	1775	M11	1	2	1	GR	22.2	22.7
60	1775	M11	1	2	1	GR	18.2	19.6
61	1779	M6	4	2	1	GR	26.8	28.6
62	1779	M6	4	2	1	GR	28.0	28.9
63	1779	M6	4	2	1	GR	25.7	28.6
64	1779	M6	4	2	1	GR	25.0	24.5

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
65	1779	M6	4	2	1	GR	25.0	33.3
66	1801	M6	2	2	1	GR	24.1	27.2
67	1801	M6	2	2	1	GR	25.0	22.5
68	74	M15	2	2	1	GR	46.7	50.0
69	74	M15	2	2	1	GR	20.0	26.5
70	74	M15	2	2	1	GR	26.2	23.8
71	74	M15	2	2	1	GR	28.1	28.6
72	74	M15	2	2	1	GR	25.0	25.5
73	74	M15	2	2	1	GR	23.1	23.7
74	916	M13	5	1	1	GR	20.3	22.7
75	916	M13	5	1	1	GR	23.1	22.6
671		M1	2	2	1	RD	26.6	28.3
672	157	M3	3	1	1	RD	20.2	23.1
673	157	M3	3	1	1	RD	25.0	26.2
674	378	M3	4	2	1	RD	22.2	23.4
675	182	M3	1	1	1	RD	20.9	23.9
676	237	M3	1	2	1	RD	22.1	23.3
677	1130	M7	3	8	1	RD	24.2	22.5
678	870	M7	3	1	1	RD	21.6	23.6
679	24	M10	2	1	1	RD	27.0	28.3
680	476	M10	6	1	1	RD	34.8	26.7
681	28	M12	1	1	1	RD	23.3	23.0
682	28	M12	1	1	1	RD	17.0	15.3
683	564	M12	4	1	1	RD	18.8	21.2
684	654	M12	4	3	1	RD	26.2	25.5
685	325	M12	1	5	1	RD	26.2	22.8
686	91	M12	3	2	1	RD	28.8	28.6
687	564	M12	4	1	1	RD	14.5	14.8
688	77	M12	1	2	1	RD	23.4	22.7
689	325	M12	1	5	1	RD	21.4	22.1
690	9	M15	1	0	1	RD	20.5	18.0
691	21	M15	1	1	1	RD	20.6	21.8
692	21	M15	1	1	1	RD	19.0	16.9
693	82	M15	1	3	1	RD	18.5	17.7
694	126	M15	1	4	1	RD	27.9	27.7
695	177	M15	1	7	1	RD	27.1	27.4
696	21	M15	1	1	1	RD	22.1	22.1
697	82	M15	1	3	1	RD	23.5	19.7
698	134	M15	1	5	1	RD	24.3	27.8
699	250	M15	1	10	1	RD	23.6	25.3
700	1375	GH	9	2	1	RD	19.0	19.1
701	2045	GH	12	5	1	RD	16.6	18.6
702	2110	GH	12	6	1	RD	21.7	23.1
703	2215	GH	12	8	1	RD	20.0	16.4
704	1981	GH	15	1	1	RD	19.5	19.4
705	2071	GH	15	2	1	RD	25.0	26.2
706	2179	GH	15	3	1	RD	21.2	20.4

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
707	2519	GH	16	6	1	RD	17.9	21.1
709	1277	GH	9	1	1	RD	24.4	23.2
710	1274	GH	10	1	1	RD	24.4	22.2
711	1380	GH	10	2	1	RD	25.6	26.1
712	2045	GH	12	5	1	RD	20.2	22.5
713	2110	GH	12	6	1	RD	17.5	21.3
714	2162	GH	12	7	1	RD	15.3	21.7
715	2215	GH	12	8	1	RD	19.1	20.1
716	1981	GH	15	1	1	RD	23.4	22.1
717	2071	GH	15	2	1	RD	25.2	23.3
718	2179	GH	15	3	1	RD	18.6	21.1
719	2179	GH	15	3	1	RD	22.5	23.6
720	2519	GH	16	6	1	RD	20.0	21.3
721	2367	GH	17	1	1	RD	20.8	17.8
722	2395	GH	17	2	1	RD	23.2	21.0
723	2471	GH	17	4	1	RD	25.0	26.8
724	2562	GH	17	5	1	RD	24.8	27.8
725	2597	GH	17	6	1	RD	19.3	22.0
728	1083	RB2	4	1	1	RD	22.6	26.1
729	1083	RB2	4	1	1	RD	26.1	26.6
730	917	GH	5	1	1	RD	26.3	25.2
731	917	GH	5	1	1	RD	21.2	22.4
732	917	GH	5	1	1	RD	20.0	24.1
733	917	GH	5	1	1	RD	19.3	19.4
734	917	GH	5	1	1	RD	18.0	20.7
735	947	GH	5	2	1	RD	19.3	18.9
736	947	GH	5	2	1	RD	26.3	25.0
737	1045	GH	5	5	1	RD	20.5	18.9
738	1054	GH	5	6	1	RD	24.6	26.9
739	1054	GH	5	6	1	RD	21.8	18.1
740	1089	GH	5	7	1	RD	25.0	26.2
741	1089	GH	5	7	1	RD	16.5	16.6
742	1089	GH	5	7	1	RD	18.9	18.8
743	928	GH	6	1	1	RD	28.9	27.1
744	928	GH	6	1	1	RD	28.4	28.1
745	1020	GH	6	1	4	RD	19.0	17.9
746	1020	GH	6	1	4	RD	19.6	24.7
747	1220	GH	6	2	4	RD	21.9	21.9
748	1061	GH	6	1	5	RD	22.7	22.6
749	1228	GH	6	1	7	RD	21.7	23.9
750	1228	GH	6	1	7	RD	22.9	22.6
751	1228	GH	6	1	7	RD	27.5	29.9
752	1228	GH	6	1	7	RD	25.0	25.7
753	1428	GH	6	2	7	RD	21.9	27.2
754	1428	GH	6	2	7	RD	17.7	15.2
755	1428	GH	6	2	7	RD	25.0	27.3
756	969	GH	7	1	1	RD	24.4	23.1

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
757	969	GH	7	1	1	RD	16.7	20.3
758	969	GH	7	1	1	RD	23.5	24.7
759	969	GH	7	1	1	RD	25.0	23.1
760	969	GH	7	1	1	RD	22.9	22.7
762	1023	GH	7	2	1	RD	18.4	21.7
763	1023	GH	7	2	1	RD	27.1	23.5
764	1413	GH	9	3	1	RD	20.3	20.3
765	1413	GH	9	3	1	RD	18.3	19.1
766	1413	GH	9	3	1	RD	27.0	27.2
768	1380	GH	10	2	1	RD	22.2	22.5
769	1177	M1	4	1	1	RD	21.7	22.8
770	1337	M1	5	1	1	RD	18.1	22.1
771	1337	M1	5	1	1	RD	26.0	24.3
772	916	M13	5	1	1	RD	25.0	21.3
773	1337	M1	5	1	1	RD	24.6	23.8
774	894	M7	1	1	1	RD	28.8	21.8
775	982	M7	3	4	1	RD	20.8	20.2
776	982	M7	3	4	1	RD	21.1	21.1
777	899	M13	3	1	1	RD	24.7	27.1
445	686	M1	3	3	1	WH	23.8	24.4
446	691	M1	3	5	1	WH	24.6	24.2
447	672	M1	2	5	1	WH	22.2	22.2
448	1177	M1	4	1	1	WH	25.0	25.4
449	201	M3	3	2	1	WH	23.4	25.4
450	255	M3	4	0	1	WH	23.7	24.2
451	378	M3	4	2	1	WH	17.3	18.2
452	299	M3	1	3	1	WH	22.7	21.8
453	1002	M7	3	5	1	WH	24.2	25.0
454	930	M7	3	2	1	WH	17.3	22.1
455	396	M12	1	7	1	WH	18.4	23.0
456	623	M12	4	2	1	WH	21.8	23.7
457	787	M12	1	2	1	WH	22.2	24.3
458	43	M12	3	1	1	WH	19.1	22.4
459	91	M12	3	2	1	WH	23.8	27.7
460	564	M12	4	1	1	WH	18.1	20.3
461	564	M12	4	1	1	WH	22.7	24.8
462		M12	2	1	1	WH	22.0	24.1
463	275	M12	1	3	1	WH	15.6	16.4
464	325	M12	1	5	1	WH	24.7	24.3
465	21	M15	1	1	1	WH	20.9	25.4
466	70	M15	1	2	1	WH	20.0	21.9
467	82	M15	1	3	1	WH	21.1	21.9
468	177	M15	1	7	1	WH	27.3	25.7
469	226	M15	1	9	1	WH	19.0	24.0
470	250	M15	1	10	1	WH	22.3	24.4
471	96	M15	21	3	1	WH	25.0	21.1
472	70	M15	1	2	1	WH	13.0	13.7

#	Sp	Ar	Un	Le	Lo	Wr	Por	R Por
473	82	M15	1	3	1	WH	24.7	24.7
474	36	M15	2	1	1	WH	13.3	14.5
475	2110	GH	12	6	1	WH	28.6	29.6
476	1380	GH	10	2	1	WH	22.5	22.9
477	1387	GH	10	3	1	WH	23.5	22.7
478	1962	GH	12	4	1	WH	26.8	28.6
479	2162	GH	12	7	1	WH	22.8	25.0
480	2179	GH	15	3	1	WH	26.7	25.9
481	2179	GH	15	3	1	WH	21.9	22.0
482	2519	GH	16	6	1	WH	20.0	23.9
483	2437	GH	17	3	1	WH	19.6	22.2
484	2471	GH	17	4	1	WH	21.1	23.1
485	2562	GH	17	5	1	WH	25.0	26.9
486	2562	GH	17	5	1	WH	27.8	26.1
487	2162	GH	12	7	1	WH	16.2	23.2
488	1277	GH	9	1	1	WH	27.3	28.0
489	1274	GH	10	1	1	WH	24.6	26.4
490	1687	GH	10	3	1	WH	27.3	29.7
491	1407	GH	10	4	1	WH	15.9	19.4
492	1407	GH	10	4	1	WH	23.9	25.6
494	2215	GH	12	8	1	WH	19.4	24.5
495	2215	GH	12	8	1	WH	19.2	22.5
496	1981	GH	15	1	1	WH	21.3	22.7
497	2071	GH	15	2	1	WH	20.6	25.0
498	2179	GH	15	3	1	WH	19.4	23.5
499	2519	GH	16	6	1	WH	23.4	26.2
500	2367	GH	17	1	1	WH	22.7	24.5
501	2562	GH	17	5	1	WH	22.1	26.7
502	2562	GH	17	5	1	WH	14.0	21.8

APPENDIX I: Temper Analysis Raw Data, Cox Ranch Pueblo

(W=Ware: gray, brown, decorated; T=Total Temper, %S=Sand, BS=Basalt Sand, yes/no; SH=Sand Shape, SS=Sand Size, %R=Rock, CB=Crushed Basalt, yes/no; RS=Rock Size, %Sd=Sherd, t=low, l=medium, h=high, r=round, s=subround, a=angular, y=yes, n=no, f=fine, m=medium, c=coarse)

#	W	T	%S	BS	SH	SS	%R	CB	RS	%Sd
1	G	t	0	n			0	n		t
2	G	l	t	n	r	m	0	n		t
3	G	h	0	n			0	n		h
4	G	l	t	n	s	m	0	n		t
5	G	l	l	n	s	m	0	n		
6	G	l	l	n	s	m	0	n		
7	G	l	l	y	s	m	0	n		t
8	G	l	l	n	s	m	0	n		l
9	G	t	t	n	r	m	0	n		
10	G	h	t	n	r	f	0	n		h
11	G	l	l	n	s	f	0	n		t
12	G	l	l	n	s	c	0	n		
13	G	h	h	n	s	c	0	n		
14	G	h	h	n	s	m	0	n		
15	G	l	l	y	s	f	0	n		t
16	G	l	l	n	s	m	0	n		l
17	G	h	h	n	s	c	0	n		
18	G	h	h	y	s	m	0	n		
19	G	h	l	n	s	m	0	n		h
20	G	h	h	n	s	m	0	n		
21	G	l	t	y	s	f	0	n		l
22	G	l	t	n	s	f	0	n		l
23	G	h	h	n	s	c	0	n		
24	G	l	t	n	s	m	0	n		l
25	G	h	h	n	r	m	0	n		
26	G	l	l	n	s	m	0	n		t
27	G	h	h	n	s	m	0	n		
28	G	l	t	y	s	m	0	n		t
29	G	l	t	y	s	f	0	n		l
30	G	h	h	n	r	m	0	n		
31	G	h	h	y	s	m	0	n		
32	G	l	0	n			0	n		l
33	G	l	l	y	s	m	0	n		
34	G	l	0	n			0	n		l
35	G	l	l	n	s	f	0	n		t
36	G	l	0	n			0	n		l
37	G	h	h	n	r	m	0	n		t
38	G	l	l	y	s	f	0	n		l
39	G	l	l	n	s	m	0	n		
40	G	h	h	n	r	f	0	n		t
41	G	h	h	n	s	m	0	n		
42	G	l	l	y	s	f	0	n		
43	G	h	h	n	s	c	0	n		
44	G	l	h	y	s	m	0	n		
45	G	l	t	n	s	m	0	n		t
46	G	l	l	n	s	f	0	n		t
47	G	l	t	n	s	f	0	n		t
48	G	t	t	n	s	f	0	n		t
49	G	l	t	n	s	f	0	n		t
50	G	t	t	n	s	f	0	n		
51	G	l	t	n	s	f	0	n		t
52	G	l	t	n	s	f	0	n		t
53	G	h	t	n	s	f	0	n		l
54	G	l	t	n	s	f	0	n		t
55	G	t	t	n	s	f	0	n		t
56	G	t	t	n	s	f	0	n		t
57	G	h	h	n	s	c	0	n		t
58	G	l	t	y	s	f	0	n		l
59	G	t	t	n	s	m	0	n		t
60	G	l	l	y	s	f	0	n		t
61	G	h	t	n	s	f	0	n		l
62	G	t	t	n	r	f	0	n		0
63	G	t	t	y	s	f	0	n		t
64	G	h	l	y	s	m	0	n		l
65	G	l	t	n	s	f	0	n		t
66	G	t	t	n	s	f	0	n		t
67	G	t	t	y	s	f	0	n		t
68	G	t	0	n			0	n		t
69	G	l	t	y			0	n		t
70	G	l	l	n	s	m	0	n		t
71	G	t	t	n	s	f	0	n		
72	G	t	t	n	s	f	0	n		t
73	G	l	t	n	s	f	0	n		l
74	G	l	t	n	s	m	0	n		t
75	G	t	t	n	s	f	0	n		t
76	B	h	h	n	s	m	0	n		0
77	B	l	0	n			l	n	m	0
78	B	h	0	n			h	n	c	0
79	B	l	t	n	r	m	l	n	m	0
80	B	h	0	n			h	n	m	0
81	B	h	h	n	a	c	0	n		0

#	W	T	% S	B S	S H	S S	% R	C B	R S	% Sd
82	B	h	h	n	s	f	0	n		t
83	B	h	0	n			h	n	c	0
84	B	h	0	n			h	n	m	0
85	B	h	h	n	s	m	0	n		t
86	B	h	t	n	s	m	h	n	m	0
87	B	h	h	n	s	m	0	n		0
88	B	h	0	n			h	n	m	0
89	B	h	0	n			h	n	m	0
90	B	h	0	n			h	n	m	0
91	B	h	0	n			h	n	m	0
92	B	h	0	n			h	n	m	0
93	B	h	l	n	s	m	l	n	c	0
94	B	h	h	y	s	m	0	n		0
95	B	h	h	y	s	f	0	n		0
96	B	h	0	n			h	n	m	0
97	B	h	h	n	s	m	0	n		0
98	B	h	0	n			h	n	m	0
99	B	l	l	n	s	m	0	n		0
100	B	h	l	n	s	m	l	n	f	0
101	B	l	l	y	s	m	0	n		0
102	B	h	h	n	s	m	0	n		0
103	B	h	t	n	s	m	h	n	m	0
104	B	h	h	y	s	m	0	n		0
105	B	h	h	y	s	m	l	n	m	0
106	B	h	t	y	s	m	h	n	m	0
107	B	h	l	y	s	m	l	n	m	0
108	B	l	l	n	s	m	t	n	m	t
109	B	l	l	y	s	m	t	n	m	0
110	B	h	t	n	r	m	h	n	m	0
111	B	h	h	n	s	m	t	n	m	0
112	B	h	0	n			h	y	m	0
113	B	h	h	y	s	f	0	n		0
114	B	h	h	y	s	f	0	n		l
115	B	h	t	y	s	m	h	n	m	0
116	B	h	h	y	s	m	t	n	m	0
117	B	h	0	n			h	y	m	0
118	B	h	h	n	s	m	0	n		0
119	B	h	h	n	r	m	0	n		0
120	B	l	l	n	s	f	l	n	m	0
121	B	h	l	n	r	m	l	n	m	0
122	B	h	l	n	r	m	l	n	c	0
123	B	l	h	y	s	m	0	n		0
124	B	h	h	y	s	m	0	n		0
125	B	h	h	n	s	f	0	n		0
126	B	h	h	n	s	c	0	n		0

#	W	T	% S	B S	S H	S S	% R	C B	R S	% Sd
127	B	h	h	n	s	c	0	n		0
128	B	h	0	n			h	n	c	0
129	B	l	t	n	s	f	l	n	c	0
130	B	l	l	n	s	f	0	n		0
131	B	h	h	n	s	c	0	n		0
132	B	h	h	n	r	m	0	n		0
133	B	l	l	n	r	f	0	n		0
134	B	l	l	n	s	m	t	n	c	0
135	B	h	t	n	s	f	l	n	c	0
136	B	l	l	n	s	m	0	n		0
137	B	h	h	y	s	m	0	n		0
138	B	l	t	n	s	f	l	n	m	0
139	B	l	t	y	s	f	l	n	m	0
140	B	h	0	n			h	n	c	0
141	B	h	h	y	s	m	t	n	c	0
142	B	l	h	n	s	f	t	n	m	0
143	B	h	0	n			h	n	m	0
144	B	h	0	n			h	n	m	0
145	B	h	0	n			h	n	m	0
146	B	l	h	n	s	m	0	n		0
147	B	l	t	n	s	f	l	n	m	0
148	B	h	0	n			h	n	c	0
149	B	l	h	n	s	f	0	n		0
150	B	h	0	n			h	y	m	0
151	B	l	h	n	s	f	0	n		0
152	B	l	l	n	s	m	0	n		t
153	B	h	0	n			h	n	c	0
154	B	l	t	n	s	f	h	n	m	0
155	B	h	h	n	s	m	0	n		0
156	B	h	h	y	s	m	0	n		0
157	B	h	h	n	s	f	0	n		0
158	B	h	0	n			h	n	m	0
159	B	h	l	n	s	f	h	n	f	0
160	B	l	h	n	s	f	t	n	f	0
161	B	h	h	n	r	f	l	n	f	0
162	B	l	h	n	s	m	l	n	m	0
163	B	h	h	n	s	f	l	n	f	0
164	B	l	h	n	s	f	t	n	f	0
165	B	h	0	n			h	n	m	0
166	B	l	h	n	s	m	0	n		0
167	B	l	h	y	s	m	0	n		0
168	B	l	h	n	s	f	0	n		0
169	B	h	h	n	s	f	l	n	f	0
170	B	h	0	n			h	y	m	0
171	B	h	h	n	r	m	0	n		0

#	W	T	% S	B S	S H	S S	% R	C B	R S	% Sd
172	B	h	h	n	s	m	t	n	m	0
173	B	h	h	n	s	m	0	n		0
174	B	h	0	n			h	y	c	0
175	B	h	0	n			h	n	c	0
176	B	h	0	n			h	n	m	0
177	B	l	h	n	s	f	0	n		0
178	B	h	0	n			h	n	m	0
179	B	h	h	y	s	m	l	n n	m	0
180	B	h	t	y	a	f	h	n	m	0
181	B	h	h	n	r	m	l	n	m	0
182	B	h	0	n			h	n	c	0
183	B	h	h	y	s	m	l	n	m	0
184	B	h	h	n	s	m	l	n	m	0
185	B	h	l	y	s	m	l	n	m	0
186	B	h	0	n			h	y	m	0
187	B	h	h	y	s	m	0	n		0
188	B	h	h	n	r	m	0	n		0
189	B	h	h	n	s	m	0	n		0
190	B	h	0	n			h	y	m	0
191	B	h	0	n			h	n	m	0
192	B	h	h	n	s	m	0	n		0
193	B	h	h	n	s	m	0	n		0
194	B	l	l	y	s	m	0	n		0
195	B	h	h	y	s	f	0	n		0
196	B	h	l	y	s	m	l	n	m	0
197	B	h	t	y	s	m	h	n	m	0
198	B	h	h	y	a	m	0	n		0
199	B	h	h	y	s	m	0	n		0
200	B	h	0	n			h	y	m	0
201	B	h	l	y	s	m	l	n	m	0
202	B	h	h	n	s	m	0	n		0
203	B	h	h	n	s	m	0	n		0
204	B	h	h	y	s	m	0	n		0
205	B	h	h	y	s	m	l	n	m	0
206	B	h	t	y	s	m	h	n	m	0
207	B	h	t	y	s	m	h	n	m	0
208	B	h	0	n			h	y	m	0
209	B	l	l	y	s	m	t	n	m	0
210	B	h	l	y	s	f	l	n	m	0
211	B	h	h	y	s	f	0	n		0
212	B	h	l	y	s	m	h	n	m	0
213	B	h	h	n	s	f	t	n	m	0
214	B	h	h	y	r	m	t	n	m	0
215	B	h	t	y	s	m	h	n	m	0

#	W	T	% S	B S	S H	S S	% R	C B	R S	% Sd
216	B	h	h	y	s	m	0	n		0
217	B	h	h	n	s	f	t	y	m	0
218	B	l	l	n	s	f	t	n	m	0
219	B	l	0	n			h	y	m	0
220	B	h	h	n	s	c	0	n		t
221	B	l	t	n	s	f	l	n	m	0
222	B	l	l	n	s	f	0	n		0
223	B	h	0	n			h	n	m	0
224	B	l	l	n	r	f	0	n		0
225	B	h	h	y	s	m	0	n		0
226	B	h	0	n			h	n	m	0
227	B	l	t	n	r	f	l	n	m	0
228	B	l	l	n	s	m	t	n	c	0
229	B	l	l	n	r	f	0	n		0
230	B	h	0	n			h	n	m	0
231	B	l	l	n	s	m	0	n		0
232	B	l	l	n	s	f	0	n		0
233	B	h	h	n	s	m	0	n		0
234	B	l	l	n	s	m	t	n	m	0
235	B	h	0	n			h	n	c	0
236	B	h	h	n	s	c	0	n		0
237	B	h	0	n			h	n	f	0
238	B	h	0	n			h	y	m	0
239	B	h	0	n			h	y	m	0
1	D	l	0	n			0	n		l
2	D	h	t	n	r	m	0	n		h
3	D	h	0	n			0	n		h
4	D	l	0	n			0	n		l
5	D	l	0	n			0	n		l
6	D	h	l	y	s	f	0	n		l
7	D	h	t	y	r	m	0	n		h
8	D	h	l	y	r	f	0	n		h
9	D	h	l	n	s	f	0	n		h
10	D	h	l	y	r	m	0	n		h
11	D	l	0	n			0	n		l
12	D	h	l	n	r	m	0	n		l
13	D	h	0	n			0	n		h
14	D	h	t	n	s	m	0	n		h
15	D	h	l	y	s	m	0	n		l
16	D	h	t	y	s	f	0	n		h
17	D	h	t	y	s	f	0	n		h
18	D	h	t	y	s	m	0	n		h
19	D	l	0	n			0	n		l
20	D	h	t	y	a	f	0	n		h
21	D	l	t	n	r	m	0	n		l

#	W	T	% S	B S	S H	S S	% R	C B	R S	% Sd
22	D	l	0	n			0	n		l
23	D	l	0	n			0	n		l
24	D	h	l	y	s	f	0	n		l
25	D	h	t	n	r	m	0	n		h
26	D	h	t	y	r	m	0	n		h
27	D	h	l	y	s	m	0	n		l
28	D	l	t	n	s	m	0	n		l
29	D	h	l	n	r	f	0	n		h
30	D	h	t	n	r	m	0	n		h
31	D	l	t	y	s	f	0	n		l
32	D	h	l	y	s	f	0	n		h
33	D	h	t	y	s	f	0	n		h
34	D	h	0	n			0	n		h
35	D	h	t	n	r	m	0	n		h
36	D	l	t	y	r	f	0	n		l
37	D	h	t	y	r	f	0	n		h
38	D	l	0	n			0	n		l
39	D	h	t	n	r	m	0	n		h
40	D	h	0	n			0	n		h
41	D	l	0	n			0	n		l
42	D	l	t	y	r	f	0	n		l
43	D	h	t	y	r	m	0	n		h
44	D	h	0	n			0	n		h
45	D	l	t	n	r	f	0	n		l
46	D	h	t	n	r	f	0	n		h
47	D	h	0	n			0	n		h
48	D	l	t	n	r	f	0	n		h
49	D	l	t	y	s	f	0	n		l
50	D	l	t	n	s	f	0	n		l
51	D	h	t	n	s	f	0	n		h
52	D	l	0	n			0	n		l
53	D	l	t	n	s	f	0	n		l
54	D	l	0	n			0	n		l
55	D	t	0	n			0	n		l
56	D	h	0	n			0	n		h
57	D	l	t	n	s	f	0	n		l
58	D	l	t	n	s	f	0	n		l
59	D	l	0	n			0	n		l
60	D	h	0	n			0	n		h
61	D	h	l	y	s	f	0	n		l
62	D	l	t	y	a	f	0	n		l
63	D	l	t	y	a	f	0	n		l
64	D	l	l	n	r	m	0	n		l
65	D	l	t	n	r	m	0	n		l
66	D	l	t	y	a	f	0	n		l
67	D	l	t	n	r	m	0	n		l
68	D	l	0	n			0	n		l
69	D	l	t	y	s	f	0	n		l
70	D	h	t	y	r	f	0	n		h
71	D	l	0	n			0	n		l
72	D	l	t	n	r	m	0	n		l
73	D	l	t	n	r	m	0	n		l
74	D	l	t	n	r	f	0	n		l
75	D	h	l	y	s	f	0	n		l
76	D	l	0	n			0	n		l
77	D	h	h	y	s	m	0	n		l
78	D	h	l	y	s	f	0	n		l
79	D	l	t	n	r	f	0	n		l
80	D	h	l	y	s	m	0	n		l
81	D	l	t	y	s	f	0	n		l
82	D	l	0	n			0	n		l
83	D	h	0	n			0	n		h
84	D	h	0	n			0	n		h
85	D	l	t	n	r	f	0	n		l
86	D	l	0	n			0	n		l
87	D	l	0	n			0	n		l
88	D	l	0	n			0	n		l
89	D	l	t	n	r	f	0	n		l
90	D	l	t	n	r	f	0	n		t
91	D	l	0	n			0	n		l
92	D	l	0	n			0	n		l
93	D	t	0	n			0	n		t
94	D	l	t	n	r	f	0	n		l
95	D	l	t	n	s	f	0	n		l
96	D	l	0	n			0	n		l
97	D	l	t	n	r	f	0	n		l
98	D	l	0	n			0	n		l
99	D	l	0	n			0	n		l
100	D	l	0	n			0	n		l
101	D	l	t	n	s	f	0	n		l

APPENDIX J:
Protein Residue Analysis
of
Artifacts from Cox Ranch and Cerro Pomo Pueblos, West-central New Mexico

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(LAS-154)

June 2007

Introduction

The use of chemical and molecular biological techniques in the analysis of archaeological materials can provide significant new information for the interpretation of their past use. The identification of organic residues from lithic and ceramics artifacts, coprolites and soils have provided archaeologists with specific data regarding prehistoric exploitation of animals and plants. Although ancient protein residues may not be preserved in their original form, linear epitopes are generally conserved which can be identified by immunological methods (Abbas et al. 1994).

Immunological methods have been used to identify plant and animal residues on flaked and groundstone lithic artifacts (Allen et al. 1995; Gerlach et al. 1996; Henrikson et al. 1998; Hyland et al. 1990; Kooyman et al. 1992; Newman 1990, 1995; Petraglia et al. 1996; Shanks et al.1999; Yohe et al. 1991) and in Chumash paint pigment (Scott et al. 1996). Plant remains on artifacts also been identified through chemical (opal phytoliths), and morphological (use-wear), studies (Hardy and Garufi 1998; Jahren et al. 1997, Sobolik 1996). Plant and animal residues on ceramic artifacts have been identified through the use of gas-liquid chromatography, high performance liquid chromatography and mass spectrometry (Bonfield and Heron 1995; Evershed et al. 1992; Evershed and Tuross, 1996; Heron et al. 1991, Patrick et al. 1985). Serological methods have been used to determine blood groups in skeletal and soft tissue remains (Heglar 1972; Lee et al. 1989) and in the detection of hemoglobin from 4500-year-old bones (Ascenzi et al. 1985). Human leukocyte antigen (HLA) and deoxyribonucleic acid (DNA) determinations made on human and animal skeletal and soft tissue remains have demonstrated genetic relationships and molecular evolutionary distances (Hänni et al. 1995; Hansen and Gurtler 1983; Lowenstein 1985, 1986; Pääbo 1985, 1986, 1989; Pääbo et al. 1989). Successful identification of residues on stone tools dated between 35-60,000 B.P. has been made by DNA analysis (Hardy et al. 1997, while residues on surgical implements from the American Civil War were recently identified by immunological and DNA analysis (Newman et al. 1998). A recent study demonstrated the viability of identifiable immunoglobulin G in 1.6 million-year-old fossil bones from Venta Micena, Spain, (Torres et al. 2002). Horse exploitation was identified by immunological analysis of residues retained on Clovis points dated to ca. 11, 200 B. P. (Kooyman et al. 2001).

The use of forensic techniques in the investigation of archaeological materials is appropriate as both disciplines deal with residues that have undergone changes, either deliberate or natural. Criminals habitually endeavor to remove bloodstains by such means as laundering, scrubbing with bleach, etc. yet; such degraded samples are still identified by immunological methods (Lee and De Forest 1976; Milgrom and Campbell 1970; Shinomiya et al. 1978, among others). Similarly it has been shown that immunological methods can be successfully applied to ancient human cremations (Cattaneo et al. 1994). Forensic wildlife laboratories use immunological techniques in their investigation of hunting violations and illegal trade, often from contaminated evidence (Bartlett and Davidson 1992; Guglich et al. 1994; Mardini 1984; McClymont et al. 1982; among others). Immunological methods are also used to test the purity of food products such as canned luncheon meat and sausage, products which have undergone considerable degradation (Ashoor et al. 1988; Berger et al. 1988; King 1984). Thus the age and degradation of protein does not preclude detection (Gaensslen 1983:225).

Materials and Methods

The method of analysis used in this study of archaeological residues is cross-over electrophoresis (CIEP). Prior to the introduction of DNA fingerprinting this test was used by forensic laboratories to identify trace residues from crime scenes. Minor adaptations to the original method were made following procedures used by the Royal Canadian Mounted Police Serology Laboratory, Ottawa (1983) and the Centre of Forensic Sciences (Toronto). The solution used to remove possible residues is 5% ammonium hydroxide which is the most effective extractant for old and denatured bloodstains without interfering with subsequent testing (Dorrill and Whitehead 1979; Kind and Cleevely 1969). Artifacts are placed in shallow plastic dishes and 0.5 ml of 5% ammonia solution applied directly to each. Initial disaggregation is carried out by floating the dish and contents in an ultrasonic cleaning bath for five minutes. Extraction is continued by placing the dish and contents on a rotating mixer for thirty minutes. In the case of large, heavy milling tools, 1.0 ml or more of the ammonium solution is applied directly to a working surface, agitated with a sterile spatula and allowed to sit for 35 minutes. The resulting ammonia solutions are removed and placed in numbered, sterile, plastic vials and stored at -20□C prior to testing.

A series of paired wells is punched into an agarose gel. About 4 µl of antiserum is placed into one well and the same amount of the sample extract is placed in the other. An electric current is then passed through the gel. The antiserum and unknown sample migrate through the gel and come into contact. If there is protein in the unknown which corresponds with the antiserum, an antigen-antibody reaction occurs and the protein precipitates out in a specific pattern. The precipitant is detected when the gel is pressed, dried and stained. Control positives are run simultaneously with all the unknown samples. Sterile equipment and techniques are use throughout the analysis.

The Samples

Four ceramic sherd samples collected from Cox Ranch and Cerro Pomo Pueblos in west-central New Mexico were submitted for immunological analysis by Washington State University in Pullman, Washington. Residues were removed from the artifacts as discussed above. Testing of the samples was performed against the animal antisera shown in Table 1. Animal antisera produced by Cappel Research, and plant antisera produced at the University of Calgary and Cedarlane Laboratory, provide family level identification only. The relationship of antisera to possible species identified is shown in Table 2.

Results

No positive reactions were registered (Table 3). The absence of identifiable proteins on the artifacts may be due to poor preservation of protein, insufficient protein, or that they were not used on any of the organisms included in the available antisera.

TABLE 1: ANTISERA USED IN ANALYSIS

Antiserum	Source
Bear	Cappel Research
Bovine	
Cat	“
Chicken	“
Deer	“
Dog	“
Guinea-pig	“
Horse	
Rabbit	“
Rat	“
Sheep	“
Swine	“
Agavaceae	University of Calgary
Amaranthaceae	“
Asteraceae	“

Cactus	"
Capparidaceae	"
Cedar	"
Chenopodiaceae	"
Lamiaceae	"
Kelp	Cedarlane Laboratory
Malvaceae	University of Calgary
Fabaceae	"
Pine	"
Poaceae	"
Walnut	"

TABLE 2: POSSIBLE SPECIES IDENTIFIED

Antiserum	Possible Species Identified
Bear	black, grizzly
Bovine	bison, cow,
Cat	bobcat, lynx, mountain lion
Chicken	turkey, quail, grouse, & other gallinaceous fowl
Deer	deer, elk, caribou, moose
Dog	coyote, wolf, dog
Guinea-pig	beaver, porcupine, squirrel
Horse	donkey, horse
Rabbit	rabbit, hare, pika
Rat	all mouse and rat species
Sheep	bighorn and other sheep
Swine	pig, possibly javelina
Agavaceae	agave, yucca
Amaranthaceae	amaranth, pigweed, quelite, etc.
Asteraceae	rabbitbrush, sagebrush, sunflower, thistle
Cactaceae	cacti
Capparidaceae	beeplant, bladderpod, stinkweed, etc.
Cedar	cedar, cypress, juniper
Chenopodiaceae	greasewood, goosefoot, pickleweed, saltbush
Lamiaceae	chia
Kelp	kelp, possibly algae
Malvaceae	mallows
Fabaceae	mesquite, palo verde, other legumes
Pine	fir, hemlock, pine, spruce
Poaceae	grasses
Walnut	walnut, hickory

TABLE 3: RESULTS

Sample No.	Artifact	Results
1932	ceramic	negative
2564	ceramic	negative
2913	ceramic	negative
3105	ceramic	negative

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APPENDIX K:

Analysis of the Fatty Acid Compositions of
Archaeological Pottery from the
Cerro Pomo and Cox Ranch Great Houses.

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Introduction

Six fragments of archaeological pottery were submitted for analysis; subsamples were taken from large vessel sections. Exterior surfaces were ground off to remove any contaminants and samples were crushed. Absorbed lipid residues were extracted with organic solvents. Fatty acid components of the lipid extracts were analyzed using gas chromatography. Residues were identified using criteria developed from the decomposition patterns of experimental residues. The first section of this report outlines the development of the identification criteria. Following this, analytical procedures and results are presented.

Fatty Acids and Development of the Identification Criteria

Introduction and Previous Research

Fatty acids are the major constituents of fats and oils (lipids) and occur in nature as triglycerides, consisting of three fatty acids attached to a glycerol molecule by ester-linkages. The shorthand convention for designating fatty acids, Cx:yωz, contains three components. The "Cx" refers to a fatty acid with a carbon chain length of x number of atoms. The "y" represents the number of double bonds or points of unsaturation, and the "ωz" indicates the location of the most distal double bond on the carbon chain, i.e. closest to the methyl end. Thus, the fatty acid expressed as C18:1ω9, refers to a mono-unsaturated isomer with a chain length of 18 carbon atoms with a single double bond located nine carbons from the methyl end of the chain. Similarly, the shorthand designation, C16:0, refers to a saturated fatty acid with a chain length of 16 carbons.

Their insolubility in water and relative abundance compared to other classes of lipids, such as sterols and waxes, make fatty acids suitable for residue analysis. Since employed by Condamin *et al.* (1976), gas chromatography has been used extensively to analyze the fatty acid component of absorbed archaeological residues. The composition of uncooked plants and animals provides important baseline information, but it is not possible to directly compare modern uncooked plants and animals with highly degraded archaeological residues. Unsaturated fatty acids, which are found widely in fish and plants, decompose more readily than saturated fatty acids, sterols or waxes. In the course of decomposition, simple addition reactions might occur at points of unsaturation (Solomons 1980) or peroxidation might lead to the formation of a variety of volatile and non-volatile products which continue to degrade (Frankel 1991). Peroxidation occurs most readily in fatty acids with more than one point of unsaturation.

Attempts have been made to identify archaeological residues using criteria that discriminate uncooked foods (Marchbanks 1989; Skibo 1992; Loy 1994). Marchbanks' (1989) percent of saturated fatty acids (%S) criteria has been applied to residues from a variety of materials including pottery, stone tools and burned rocks (Marchbanks 1989; Marchbanks and Quigg 1990; Collins *et al.* 1990). Skibo (1992:89) could not apply the %S technique and instead used two ratios of fatty acids, C18:0/C16:0 and C18:1/C16:0. He (1992) reported that it was possible to link the uncooked foods with residues extracted from modern cooking pots actively used to prepare one type of food; however, the ratios could not identify food mixtures. The utility of these ratios did not extend to residues extracted from archaeological potsherds because the ratios of the major fatty acids in the residue changed with decomposition (Skibo 1992:97). Loy (1994) proposed the use of a Saturation Index (SI), determined by the ratio: SI = 1-[(C18:1+C18:2)/C12:0+C14:0+C16:0+C18:0)]. He (1994) admitted, however, that poorly understood decompositional changes to the original suite of fatty acids make it difficult to develop criteria for distinguishing animal and plant fatty acid profiles in archaeological residues.

The major drawback of the distinguishing ratios proposed by Marchbanks (1989), Skibo (1992) and Loy (1994) is they have never been empirically tested. The proposed ratios are based on criteria that discriminate food classes on the basis of their original fatty acid composition. The resistance of these criteria to the effects of decompositional changes has not been demonstrated. Rather, Skibo (1992) found his fatty acid ratio criteria could not be used to identify highly decomposed archaeological samples.

In order to identify a fatty acid ratio unaffected by degradation processes, Patrick *et al.* (1985) simulated the long-term decomposition of one sample and monitored the resulting changes. An experimental cooking residue of seal was prepared and degraded in order to identify a stable fatty acid ratio. Patrick *et al.* (1985) found that the ratio of two C18:1 isomers, oleic and vaccenic, did not change with decomposition; this fatty acid ratio was then used to identify an archaeological vessel residue as seal. While the fatty acid composition of uncooked foods must be known, Patrick *et al.* (1985) showed that the effects of cooking and decomposition over long periods of time on the fatty acids must also be understood.

<u>Development of the Identification Criteria</u>

As the first stage in developing the identification criteria used herein, the fatty acid compositions of more than 130 uncooked Native food plants and animals from Western Canada were determined using gas chromatography (Malainey 1997; Malainey *et al.* 1999a). When the fatty acid compositions of modern food plants and animals were subject to cluster and principal component analyses, the resultant groupings generally corresponded to divisions that exist in nature (Table 1). Clear differences in the fatty acid composition of large mammal fat, large herbivore meat, fish, plant roots, greens and berries/seeds/nuts were detected, but the fatty acid composition of meat from medium-sized mammals resembles berries/seeds/nuts.

Samples in cluster A, the large mammal and fish cluster had elevated levels of C16:0 and C18:1 (Table 1). Divisions within this cluster stemmed from the very high level of C18:1 isomers in fat, high levels of C18:0 in bison and deer meat and high levels of very long chain unsaturated fatty acids (VLCU) in fish. Differences in the fatty acid composition of plant roots, greens and berries/seeds/nuts reflect the amounts of C18:2 and C18:3ω3 present. The berry, seed, nut and small mammal meat samples appearing in cluster B have very high levels of C18:2, ranging from 35% to 64% (Table 1). Samples in subclusters V, VI and VII have levels of C18:1 isomers from 29% to 51%, as well. Plant roots, plant greens and some berries appear in cluster C. All cluster C samples have moderately high levels of C18:2; except for the berries in subcluster XII, levels of C16:0 are also elevated. Higher levels of C18:3ω3 and/or very long chain saturated fatty acids (VLCS) are also common except in the roots which form subcluster XV.

Secondly, the effects of cooking and degradation over time on fatty acid compositions were examined. Originally, 19 modern residues of plants and animals from the plains, parkland and forests of Western Canada were prepared by cooking samples of meats, fish and plants, alone or combined, in replica vessels over an open fire (Malainey 1997; Malainey *et al.* 1999b). After four days at room temperature, the vessels were broken and a set of sherds analysed to determine changes after a short term of decomposition. A second set of sherds remained at room temperature for 80 days, then placed in an oven at 75°C for a period of 30 days in order to simulate the processes of long term decomposition. The relative percentages were calculated on the basis of the ten fatty acids (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11, C18:2) that regularly appeared in Precontact Period vessel residues from Western

Canada. Observed changes in fatty acid composition of the experimental cooking residues enabled the development of a method for identifying the archaeological residues (Table 2).

It was determined that levels of medium chain fatty acids (C12:0, C14:0 and C15:0), C18:0 and C18:1 isomers in the sample could be used to distinguish degraded experimental cooking residues (Malainey 1997; Malainey *et al.* 1999b). These fatty acids are suitable for the identification criteria because saturated fatty acids are stable and the mono-unsaturated fatty acid degrades very slowly, as compared to polyunsaturated fatty acids (deMan 1992). Higher levels of medium chain fatty acids, combined with low levels of C18:0 and C18:1 isomers, were detected in the decomposed experimental residues of plants, such as roots, greens and most berries. High levels of C18:0 indicated the presence of large herbivores. Moderate levels of C18:1 isomers, with low levels of C18:0, indicated the presence of either fish or foods similar in composition to corn. High levels of C18:1 isomers with low levels of C18:0, were found in residues of beaver or foods of similar fatty acid composition. The criteria for identifying six types of residues were established experimentally; the seventh type, plant with large herbivore, was inferred (Table 2). These criteria were applied to residues extracted from more than 200 pottery cooking vessels from 18 Western Canadian sites (Malainey 1997; Malainey *et al.* 1999c; 2001b). The identifications were found to be consistent with the evidence from faunal and tool assemblages for each site.

Work has continued to understand the decomposition patterns of various foods and food combinations (Malainey *et al.* 2000a, 2000b, 2000c, 2001a; Quigg *et al.* 2001). The collection of modern foods has expanded to include plants from the Southern Plains. The fatty acid compositions of mesquite beans (*Prosopis glandulosa*), Texas ebony seeds (*Pithecellobium ebano Berlandier*), tasajillo berry (*Opuntia leptocaulis*), prickly pear fruit and pads (*Opuntia* *engelmannii*), Spanish dagger pods (*Yucca treculeana*), cooked sotol (*Dasylirion wheeler*), agave (*Agave lechuguilla*), cholla (*Opuntia imbricata*), piñon (*Pinus edulis*) and Texas mountain laurel (or mescal) seed (*Sophora secundiflora*) have been determined. Experimental residues of many of these plants, alone or in combination with deer meat, have been prepared by boiling foods in clay cylinders or using sandstone for either stone boiling (Quigg *et al.* 2000) or as a griddle. In order to accelerate the processes of oxidative degradation that naturally occur at a slow rate with the passage of time, the rock or clay tile containing the experimental residue was placed in an oven at 75°C. After either 30 or 68 days, residues were extracted and analysed using gas chromatography.

The results of these decomposition studies enabled refinement of the identification criteria.

Methodology

Descriptions of the samples are presented in Table 3. Exterior surfaces were ground off using a Dremel® tool fitted with a silicon carbide bit. Immediately thereafter, the sample was crushed with a hammer mortar and pestle and the powder transferred to an Erlenmeyer flask. Lipids were extracted using a variation of the method developed by Folch *et al.* (1957). The powdered sample was mixed with a 2:1 mixture, by volume, of chloroform and methanol (2 X 25 mL) using ultrasonication (2 X 10 min). Solids were removed by filtering the solvent mixture into a separatory funnel. The lipid/solvent filtrate was washed with 13 mL of ultrapure water. Once separation into two phases was complete, the lower chloroform-lipid phase was transferred to a round-bottomed flask and the chloroform removed by rotary evaporation. Any remaining water was removed by evaporation with benzene (1.5 mL); 1.5 mL of chloroform-methanol (2:1, v/v) was used to transfer the dry total lipid extract to a screw-top glass vial with a Teflon®-lined cap. The sample was flushed with nitrogen and stored in a -20°C freezer.

A 300 µL sample of the total lipid extract solution was placed in a screw-top test tube and dried in a heating block under nitrogen. Fatty acid methyl esters (FAMES) were prepared by treating the dry lipid with 5 mL of 0.5 N anhydrous hydrochloric acid in methanol (68^{o}C; 60 min). Fatty acids that occur in the sample as di- or triglycerides are detached from the glycerol molecule and converted to methyl esters. After cooling to room temperature, 3.4 mL of ultrapure water was added. FAMES were recovered with petroleum ether (2.5 mL) and transferred to a vial. The solvent was removed by heat under a gentle stream of nitrogen; the FAMES were dissolved in 75 µL of *iso*-octane then transferred to a GC vial with a conical glass insert.

Solvents and chemicals were checked for purity by running a sample blank. The entire lipid extraction and methyl esterification process was performed and FAMES were dissolved in 75 µL of *iso*-octane. Traces of contamination were subtracted from sample chromatograms. The relative percentage composition was calculated by dividing the integrated peak area of each fatty acid by the total area of fatty acids present in the sample.

The step in the extraction procedure where the chloroform, methanol and lipid mixture is washed with water is standard procedure for the extraction of lipids from modern samples. Following Evershed *et al.* (1990), who reported that this step was unnecessary for the analysis of archaeological residues, previously the solvent-lipid mixture was not washed. This step was adopted to remove impurities so that clearer chromatograms could be obtained in the region where very long chain fatty acids (C20:0, C20:1, C22:0 and C24:0) occur. It was anticipated that the detection and accurate assessment of these fatty acids could be instrumental in separating residues of animal origin from those of plant (Malainey *et al.* 2000a, 2000b, 2000c, 2001a).

In order to identify the residue, the relative percentage composition was determined first with respect to all fatty acids present in the sample (including very long chain fatty acids) (see Table 4) and secondly with respect to the ten fatty acids utilized in the development of the identification criteria (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11 and C18:2) (not shown). The second step is necessary for the application of the identification criteria presented in Table 2.

It must be understood that the identifications given do not necessarily mean that those particular foods were actually prepared because different foods of similar fatty acid composition and lipid content would produce similar residues. It is possible only to say that the material of origin for the residue was similar in composition to the food(s) indicated.

Gas Chromatography Analysis Parameters

The GC analysis was performed on a Varian 3800 gas chromatograph fitted with a flame ionization detector connected to a personal computer. Samples were separated using a DB-23 fused silica capillary column (30 m X 0.25 mm I.D.; J&W Scientific; Folsom, CA). An autosampler injected a 3 µL sample using a split/splitless injection system. Hydrogen was used as the carrier gas with a column flow of 1.0 mL/min. Column temperature was held at 80°C for 1 minute then increased to 140°C at a rate of 20°C per minute. It was then programmed from 140 to 230°C at 4°C per minute. The upper temperature was held for 10.50 minutes. Chromatogram peaks were integrated using Varian MS Workstation® software and identified through comparisons with external qualitative standards (NuCheck Prep; Elysian, MN).

Results of Archaeological Data Analysis

The fatty acid compositions of the pottery residues are presented in Table 4. The term, Area, represents the area under the chromatographic peak of a given fatty acid, as calculated by the Varian MS Workstation® software minus the solvent blank. The term, Rel%, represents the relative percentage of the fatty acid with respect to the total fatty acids in the sample. Hydroxide or peroxide degradation products interfered with the integration of the C22:0 and C22:1 peaks; these fatty acids were excluded from the analysis.

One residue, 7CX 1, has an elevated level of C18:0 and appears to result from the preparation of large herbivore products. When the relative fatty acid composition is calculated on the basis of the ten fatty acids used to develop the criteria (described above), the level of C18:0 is 27.81%. Large herbivore residues result from the preparation of bison, deer, moose, fat elk meat or other bovines or cervids; but javelina meat and tropical oil seeds also produce residues high in C18:0 and must be considered as potential sources where available. The level of C20:0 is 5%, which may indicate the presence of plant material. The level of C16:0 in this residue is unusually high, almost 57%.

Residue 7CX 2, is similar to 7CX 1, but the level of C18:0 is below 27.5%. Levels of C18:1 isomers and medium chain fatty acids are very low; consequently, the fatty acid composition of the residue does not conform to the identification criteria. The level of C16:0 in residue 7CX 2 is over 62%, which is extraordinarily high.

Three residues, 7CX 3, 7CX 5 and 7CX 6 are characterized by levels of C18:1 isomers between 16.87% and 19.76%. Similar medium fat content levels are observed in the decomposed cooking residues of many different foods. Animal foods known to produce similar residues include freshwater fish, fat depleted elk, *Rabdotus* snails and terrapin. Plant foods known to produce similar residues include corn, mesquite beans and cholla (Malainey 2007; Table 5). Given the elevated levels of medium chain fatty acids in residues 7CX 5 and 7CX 6, they are likely to be of plant origin; the origin of 7CX 3 is ambiguous.

The level of C18:1 isomers in one residue, 7CX 4, is over 50%. Similar very high levels of C18:1 isomers are observed in the decomposed residues of very high fat content seeds or nuts, such as piñon. Rendered fats of certain mammals (other than large herbivores) exhibit similarly very high levels of C18:1 isomers, but only when fresh. This residue also has an elevated level of medium chain fatty acids and a low level of C18:0, suggesting it is from plant material.

Special Consideration of Residues with High Levels of C16:0

Four residues, 7CX 1-3 and 7CX 5, have levels of C16:0 exceeding 50%. While this fatty acid appears in all archaeological food residues, the amounts in these residues are exceptionally high. High levels of C16:0 have been observed in archaeological pottery residues from other sites in the American Southwest. In the interpretation of these residues, I suggested that the extra amounts of C16:0 may be due to a substance applied to the pots as a sealant. As the extraction technique targets absorbed residues, a sealant applied to new vessels could appear as a contaminant in the ancient food residue. If only the sealant was retained in the vessel fabric, one would expect the extracted residues to be identical. I proposed that differences in the fatty acid compositions of the vessel residues likely relate to vessel function. I assessed the degree of contamination in the vessels and reconstructed possible food residues by subtracting the C16:0 contamination.

As mentioned previously, C16:0 appears in all foods and archaeological food residues. The mean and standard deviation of C16:0 levels in 600 archaeological residues previously identified as food was determined and found to be 31 ± 9%. To reconstruct the most likely fatty acid composition of possible archaeological food residue, the relative fatty acid composition was recalculated with C16:0 at 31%, 40% and 22%. The identification of the residue at each of these levels of C16:0 was then determined.

If the same procedure is applied to the Cerro Pomo and Cox Ranch Great House pottery samples, residues 7CX 1-3 and 7CX 5 are considered to be minimally contaminated and residues 7CX 4 and 7CX 6 are free of contamination. Identifications based on the recalculated fatty acid compositions are presented in Table 4. The identification of residue 7CX 1 does not change with the recalculations; but, residue 7CX 2 is categorized as large herbivore with possible traces of plant when the relative amount of C16:0 is 31%, 40% and 22%. The effect of recalculating the relative fatty acid compositions of residues 7CX 3 and 7CX 5 is similar. The identification of the residues, originally identified as medium fat content, does not change when C16:0 is 40%. When 16:0 is 31%, levels of C18:1 isomers increase to the point that both residues fall on the border between medium and moderate-high fat content foods. When C16:0 is 22%, the levels of C18:1 in both residues increase to that of moderate-high fat content foods; however, the C18:0 levels in 7CX 3 increases to that of large herbivores. The decomposed cooking residues of the fatty meat of medium-sized mammals, such as beaver, and Texas ebony seeds have moderate-high levels of C18:1 isomers.

If the elevated levels of C16:0 are indeed due to contamination from a non-food substance, reconsideration of the fatty acid compositions of the residues is necessary. Based on the recalculated fatty acid compositions, it appears that both residues 7CX 1 and 7CX 2 result from the preparation of large herbivore products, possibly in combination with plants. Residue 7CX 3 is most likely due to the preparation of medium or moderate-high fat content foods, either of animal origin or possibly a combination of animal and plant materials. There is a slim possibility that large herbivore products are present in residue 7CX 3. Residue 7CX 5 is probably due the preparation of medium or moderate-high fat content foods of plant origin.

Further analysis with GC/MS may clarify the source of these vessel residues.

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List of Tables

Table 1. Summary of average fatty acid compositions of modern food groups generated by hierarchical cluster analysis.

Clus	A				B						C				
Sub Clus	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Typ	Mammal Fat and Marrow	Lg Herb Meat	Fish	Fish	Brs and Nuts	Mix	Seeds and Brs	Root	Seed	Mix	Grns	Brs	Root	Grns	Root
C16:0	19.90	19.3	16.0	14.1	3.75	12.06	7.48	19.9	7.52	10.33	18.71	3.47	22.6	24.19	18.7
C18:0	7.06	20.3	3.87	2.78	1.47	2.36	2.58	2.59	3.55	2.43	2.48	1.34	3.15	3.66	5.94
C18:1	56.77	35.7	18.2	31.9	51.1	35.29	29.12	6.55	10.0	15.62	5.03	14.95	12.1	4.05	3.34
C18:2	7.01	8.93	2.91	4.04	41.4	35.83	54.69	48.7	64.1	39.24	18.82	29.08	26.2	16.15	15.6
C18:3	0.68	2.61	4.39	3.83	1.05	3.66	1.51	7.24	5.49	19.77	35.08	39.75	9.64	17.88	3.42
VLCS	0.16	0.32	0.23	0.15	0.76	4.46	2.98	8.50	5.19	3.73	6.77	9.10	15.3	18.68	43.3
VLCU	0.77	4.29	39.9	24.1	0.25	2.70	1.00	2.23	0.99	2.65	1.13	0.95	2.06	0.72	1.10

VLCS- Very Long Chain (C20, C22 and C24) Saturated Fatty Acid
VLCU - Very Long Chain (C20, C22 and C24) Unsaturated Fatty Acids

Table 2. Criteria for the identification of archaeological residues based on the decomposition patterns of experimental cooking residues prepared in pottery vessels.

Identification	**Medium Chain**	**C18:0**	**C18:1 isomers**
Large herbivore	≤ 15%	≥ 27.5%	≤ 15%
Large herbivore with plant OR Bone marrow	low	≥ 25%	15% ≤ *X* ≤ 25%
Plant with large herbivore	≥ 15%	≥ 25%	no data
Beaver	low	Low	≥ 25%
Fish or Corn	low	≤ 25%	15% ≤ *X* ≤ 27.5%
Fish or Corn with Plant	≥ 15%	≤ 25%	15% ≤ *X* ≤ 27.5%
Plant (except corn)	≥ 10%	≤ 27.5%	≤ 15%

Table 3. List of pottery analyzed from the Cerro Pomo and Cox Ranch Great Houses.

Lab No.	**Great House**	**Unit**	**Level**	**Locus**	**Specimen**	**Description**	**Sample Size (g)**
7CX 1	Cerro Pomo	12	6	2	3486	Brown Plain Corrugated Plain	5.980
7CX 2	Cox Ranch	17	6	1	2597	Brown Plain Smudged	9.236
7CX 3	Cox Ranch	16	7	1	2573	Brown Indented Corrugated Smudged	11.848
7CX 4	Cox Ranch	7	3	1	1064	Puerco Black on Red	8.003
7CX 5	Cox Ranch	16	10	1	2615	Puerco Black on Red	8.185
7CX 6	Cox Ranch	17	6	1	2597	Puerco Black on Red	12.858

Table 4. Fatty acid compositions and identifications of archaeological pottery residues.

Fatty acid	7CX 1		7CX 2		7CX 3		7CX 4		7CX 5		7CX 6	
	Area	Rel%	Area	Rel %	Area	Rel %	Area	Rel %	Area	Rel%	Area	Rel %
C12:0	2051	0.18	7524	0.43	4215	0.55	7586	0.75	11585	1.17	14114	2.31
C14:0	7518	0.67	26358	1.51	18436	2.43	83000	8.21	55970	5.63	42453	6.94
C14:1	0	0.00	3645	0.21	0	0.00	0	0.00	0	0.00	11638	1.90
C15:0	11063	0.99	19765	1.13	11523	1.52	24994	2.47	34406	3.46	24898	4.07
C16:0	633659	56.71	1086854	62.17	442359	58.2	286543	28.3	512124	51.51	196827	32.2
C16:1	2306	0.21	3563	0.20	0	0.00	0	0.00	4593	0.46	4349	0.71
C17:0	17576	1.57	29816	1.71	11753	1.55	6550	0.65	13222	1.33	8892	1.45
C17:1	5341	0.48	3133	0.18	2661	0.35	0	0.00	0	0.00	0	0.00
C18:0	294007	26.31	388862	22.24	119877	15.7	54695	5.41	117063	11.77	99129	16.2
C18:1 s	88343	7.91	83928	4.80	128120	16.8	519115	51.3	196420	19.76	113717	18.6
C18:2	792	0.07	1839	0.11	271	0.04	20285	2.01	14288	1.44	3553	0.58
C18:3 w3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5721	0.94
C20:0	54712	4.90	88906	5.09	18052	2.38	4066	0.40	23173	2.33	33613	5.50
C20:1	0	0.00	4042	0.23	2323	0.31	4139	0.41	11430	1.15	4039	0.66
C24:0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	48332	7.91
Total	1117368	100	1748235	100	759590	100	1010973	100	994274	100	611275	100
ID	Large Herbivore, possibly with plant		Unknown		Medium fat content		Very high fat content		Medium fat content		Medium fat content	
Degree of C16:0 Contamin	Minimal		Minimal		Minimal		Absent		Minimal		Absent	
C16:0 = 31%	Large Herbivore, possibly with plant		Large Herbivore, possibly with plant		Borderline Medium and Moderate-High fat content		-		Borderline Medium and Moderate-High fat content		-	
C16:0 = 40%	Large Herbivore, possibly with plant		Large Herbivore, possibly with plant		Medium fat content		-		Medium fat content		-	
C16:0 = 22%	Large Herbivore, possibly with plant		Large Herbivore, possibly with plant		Moderate-High fat + Large Herbivore		-		Moderate-High fat content		-	

Table 5. Known food sources for different types of decomposed residues.

Decomposed Residue Identification	**Plant Foods Known to Produce Similar Residues**	**Animal Foods Known To Produce Similar Residues**
Large herbivore	Tropical seed oils, including sotol seeds	Bison, deer, moose, fall-early winter fatty elk meat, Javelina meat
Large herbivore with plant OR Bone marrow		
Low Fat Content Plant (Plant greens, roots, berries)	Jicama tuber, buffalo gourd, yopan leaves, biscuit root	Cooked Camel's milk
Medium-Low Fat Content Plant	Prickly pear, Spanish dagger	None
Medium Fat Content (Fish or Corn)	Corn, mesquite beans, cholla	Freshwater fish, *Rabdotus* snail, terrapin, late winter fat-depleted elk
Moderate-High Fat Content (Beaver)	Texas ebony	Beaver and probably raccoon or any other fat medium-sized mammals
High Fat Content	High fat nuts and seeds, including acorn and pecan	Rendered animal fat (other than large herbivore), including bear fat
Very High Fat Content	Very high fat nuts and seeds, including pine nuts	Freshly rendered animal fat (other than large herbivore)