COUNTING SHEEP:
FAUNA, CONTACT, AND COLONIALISM AT ZUNI PUEBLO, NEW MEXICO, A.D. 1300-1900

By

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ABSTRACT

This dissertation examines faunal assemblages from the old, ceremonial core of Zuni Pueblo, spanning the period ca. A.D. 1300-1900, to explore changes in subsistence patterns associated with the introduction of Old World domesticates. Temporal analyses of several major characteristics, including taxonomic frequency distributions, herd management strategies, butchery, and body-part representations indicate patterns consistent with the adoption and incorporation of new foods and technologies, along with a persistence of Zuni traditional practices. Sheep, a major protein and secondary product source in the Iberian subsistence system, became important at Zuni Pueblo as early as Mission times. Although the diet at Zuni appears to be predominantly Spanish (with sheep being most common), aboriginal elements such as the hunting of deer and pronghorn are maintained. This is consistent with ethnographic data on the importance of wild animals in Zuni religious life.

The analysis of sheep and goat kill-off patterns indicates that animals were mainly slaughtered at a young age, which correlates well with an emphasis on obtaining meat from flocks, but also with wool production. It is argued that this pattern might reflect the deposition of animals slaughtered for communal ritual activities in later historic times and not the general economic orientation at Zuni Pueblo. Butchery and body-part distributions indicate that animals were brought to and slaughtered in this area of the site and that the Middle Village more likely reflects a household, unspecialized, traditional butchery practice, with the Spanish influence being mostly reflected in the adoption of metal tools.

In conclusion, it is suggested that the Zuni incorporated European additions and modified previous domestic subsistence strategies, while still maintaining and perpetuating aspects of their traditional practices. The changes that took place at Zuni Pueblo after the Spanish *entrada* reflect the adoption of new dietary practices, but also an adjustment to strategies that emphasize local economic and ritual customs.

Pentru bunicii mei, Fotache şi Silvia şi pentru mama mea, Viorica

Translation in English

For my grandparents, Fotache and Silvia and my mother, Viorica

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INTRODUCTION AND RESEARCH DESIGN

Introduction

Zuni Pueblo has been studied by ethnologists, anthropologists, and archaeologists for over a century. Areas of research include: traditional history, chronology and architectural change, the Catholic Mission, human osteology, subsistence practices, material culture, ceramic seriation, pollen analyses, stratigraphy, dendrochronology, textile production, and formation processes of the archaeological record (*e.g.,* Bandelier 1890, 1892; Benedict 1935; Bunzel 1932; Caywood 1972; Cushing 1901, 1920; Dean 2003; Eggan 1950; Ferguson 2003; Ferguson and Mills 1982; Howell 2001; Howell 2003a, 2003b; Kroeber 1917; Mills and Ferguson 2003; Mills *et al.* 2003; Mindeleff 1891; Nieto and Howell 2001; Parsons 1923; Smith 2003; Smith Gebauer 2003; Spier 1917; Stevenson 1904, 1915; Thomas and Mills 2003; Webster 1997, 2000, 2003).

Research at Zuni began in 1879, under the direction of John Wesley Powell, an anthropologist interested in the historical and social development of the Zuni Indians. This was the first anthropological expedition sponsored by the Smithsonian Institution at Zuni Pueblo (Ferguson 2003). The expedition, led by James Stevenson, included Matilda Coxe Stevenson, John K. Hillers, and Frank Hamilton Cushing. Their research focused on documenting changes in material culture in the 19th century and ethnography.

Cushing made one of the most prominent ethnographic contributions to the study of Zuni Pueblo. He conducted both archaeological and ethnographic studies during his five years of residence there, from 1879 to 1884. He was an active participant in Zuni ritual and political life and was initiated as a Bow Priest in 1881 (Ferguson 2003). His monographs *Outlines of Zuni Creation Myths* (1896) and *Zuni Breadstuff* (1920) provide insight into the origins and migrations of the Zuni and "a comprehensive examination of Zuni culture through an ethnobotanical study of the ritual and economic use of maize and other cultigens" (Ferguson 2003:2). He also conducted archaeological fieldwork in the Zuni area, including surveys, site plans, and artifact collection. In 1886, Cushing returned to Zuni Pueblo for the second time, as a director of the Hemenway Expedition, which was a multidisciplinary program involving archaeological, ethnologic, historic, and biological anthropology research.

Jesse Walter Fewkes continued archaeological work in the Zuni area after Cushing's definitive departure from the Pueblo in 1888. Fewkes' work encompassed surveys and mapping of archaeological sites in the Zuni region. Architectural research started with the work of Mindeleff in 1881. His work provided details on architectural planning, growth, and development of Zuni Pueblo and other Western Pueblos. Kroeber, an advocate of the Boas anthropological school, initiated anthropological research at Zuni in 1915. He conducted a detailed study of social relations and kin life of Zuni society and used ceramic seriation to develop a chronology of settlements in Zuni area. In his monograph, *Zuni Kin and Clan* (1917), he described the relationship between Zuni social organization and architecture. Spier (1917) added stratigraphy and excavations to Krober's ceramic seriation approach to analyze the migration of the Zuni in the Zuni River Valley. Both Kroeber and Spier showed that Zuni Pueblo was occupied at least two centuries prior to the Pueblo Revolt of 1680.

The mid-twentieth century marked new research in the Zuni area, which included Hodge's excavations at the ancestral village of Hawikku, the first pueblo encountered by the Spanish during the Coronado expedition of 1539-1540. The ensuing decades encompassed ethnographic studies of Zuni pottery (*e.g.*, Bunzel 1929), oral traditions, ritual (*e.g.*, Benedict 1935; Bunzel 1932; Parsons 1923), and social organization (*e.g.*, Eggan 1950). The archaeological history at Zuni Pueblo and the formation of the pueblo are discussed in a series of articles (Woodbury 1956, 1979).

Extensive archaeological work began at Zuni Pueblo during the 1960s in the form of historic preservation projects. Caywood (1972) excavated the Spanish church, baptistry, sacristy, and *convento* to locate the walls and recover archaeological remains. Human remains found at Zuni Mission showed cranial deformations, as well as dental pathologies (Reed 1972). In 1975, the Zuni Tribe decided to undertake archaeological investigations at Zuni Pueblo as part of a cultural resource management program. Archaeological fieldwork began in 1977 on the north side of the Pueblo (Ferguson and Mills 1982), as part of the "Zuni Waterline Project". Excavations at Zuni Pueblo continued in 1983 under the direction of Susan Collins along the northern edge of the Middle Village, as part of a project to widen State Highway 53 (Ferguson 2003). Later archaeological analyses included examinations of pollen, macrobotanical, radiocarbon samples, stratigraphy, and ceramics (Hall and Ferguson 1996).

The Middle Village area, or the Old Core, of Zuni Pueblo was of major interest to archaeologists because of its long occupational span (over 600 years) and its ceremonial significance to the Zuni. Excavations in the Middle Village were carried out between 1997 and 2001 as part of a large renovation program conducted by Zuni Cultural Resource Enterprise (Howell 2001; Nieto and Howell 2001).

This dissertation uses a diachronic approach to explore changes in faunal assemblages from the Old Core of Zuni Pueblo. By using the concept of foodways, it attempts to examine and understand food-related decisions as important variables in assemblage formation. Specifically, the aim is to identify patterns of persistence in earlier practices, differential adoption, and change in foodways by looking at frequency distributions, herd management strategies, body-part representations and butchery techniques through time. The timing of the incorporation of Old World domesticates and major shifts in diet after their introduction are assessed by comparing standard taxon frequencies between five chronological sub-assemblages (*i.e.,* Late Prehistoric, Contact, Mission, Post-Revolt, and Late Historic). This chronological analysis is further employed to examine economic changes in management strategies through time (*i.e.*, Mission *versus* Late Historic times). The analysis of body-part representations and butchery patterns brings insight into intensities of adoption and incorporation of new technologies (*i.e.,* metal tools). The study explicitly includes assessments of possible sources of assemblage variability besides economic decisions such as taphonomic processes and excavation procedures.

This chapter sets the introductory theoretical framework for the study of foodways at Zuni after the Spanish *entrada* to illuminate our understanding of economic aspects in colonial settings.

Physical Setting

Zuni Pueblo is located in western central New Mexico, on the current Zuni Indian Reservation (Figure 1). The Zuni area is part of the southeastern section of the Colorado plateau and covers about 3,400 square kilometers (Crampton 1977; Dublin 1998; Ferguson and Hart 1985).

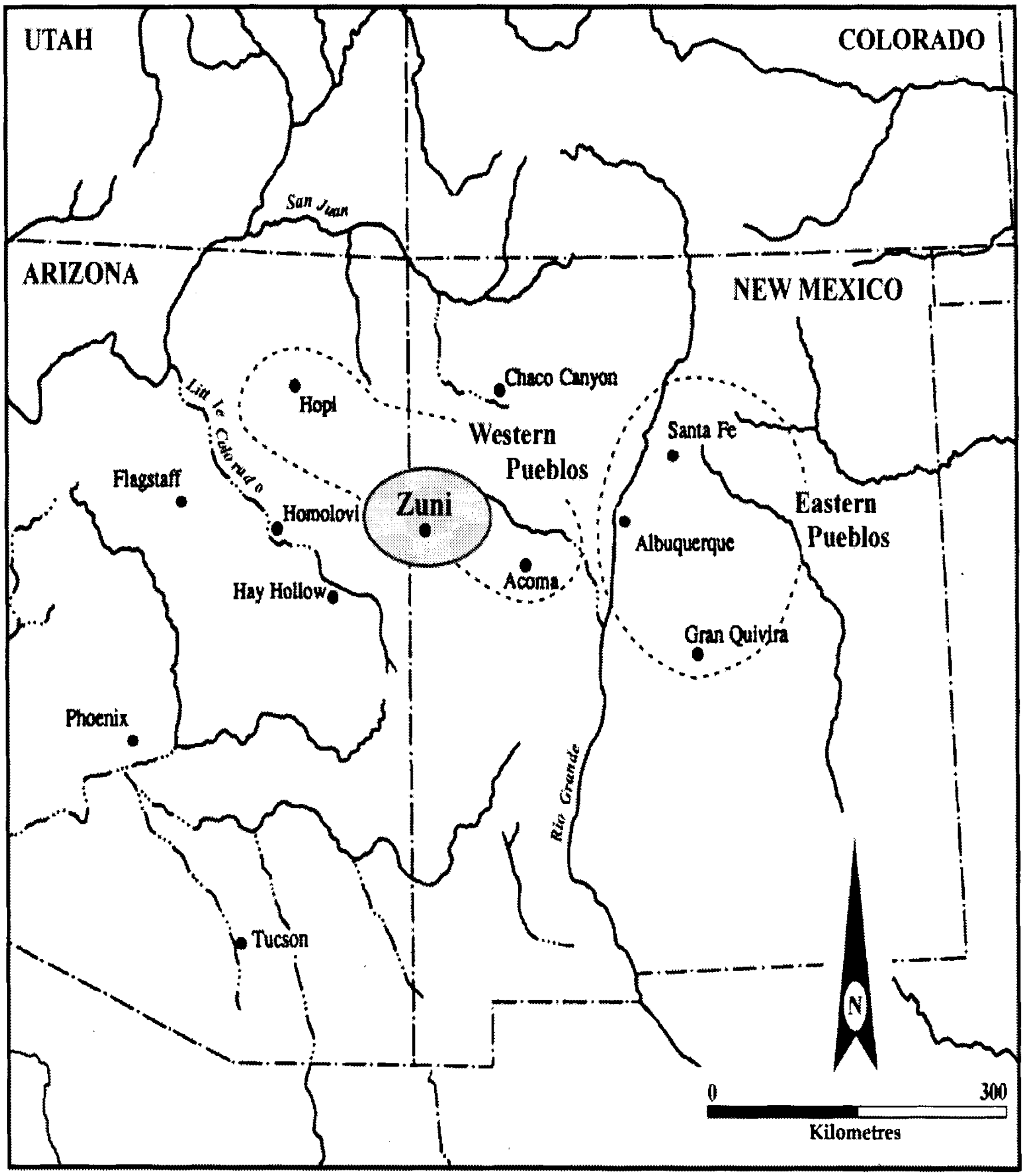

Figure 1. Location of the Zuni area in the American Southwest (based on Muir 1999:3, Figure 1).

It is bounded by Arizona to the west, the Continental Divide to the east, the Puerco River to the north, and the Mogollon Mountains to the south (Dublin 1998:36). The region is characterized by a diverse topography of landforms dominated by the massif of the Zuni Mountains in the north and northeast and Mount Taylor along the eastern border (Dublin 1998; Ferguson and Hart 1985; Ferguson and Mills 1982). Important sources of water, although intermittent today, are the Zuni River and its major tributaries, the Nutria and Pescado Rivers. The site is positioned at an elevation of 1,920 meters above sea level, in an open valley surrounded by cliffs and mesas.

Vegetation varies according to elevation, which ranges between 2,800 meters a.s.l. in the mountainous zone to 1,500 meters in the southwestern plains (Dublin 1998; Ferguson and Hart 1985). A ponderosa pine forest, associated with shrubs, herbs, grasses, oak, juniper, and pinyon trees, covers the higher zones (2,200-2,700 meters a.s.l.). At middle elevations (1,500-2,100 meters), pinyon-juniper and extensive areas of sage (a species often associated with overgrazing) are predominant. In the river valleys, a prairie vegetation consisting of grasses and low shrubs alternates with riparian plant communities along the streams (Ferguson and Hart 1985).

Animal communities are also dispersed by altitude. Elk and mountain sheep inhabited the mountainous vicinity (2,200-2,700 meters) in larger numbers in the past. Mule deer populate both high elevation and middle zones, while pronghorn, coyote, and white-tailed deer are more common at middle elevations (1,500-2,100 meters). Mid- to lower areas are colonized by smaller mammals such as cottontail, jackrabbit, prairie dog, wood rat, badger, porcupine, and several species of squirrel and rodent. Bear and deer can be found in the Zuni Mountains, east of the Pueblo. Pronghorn inhabit the drier western and southern parts of the area. Various species of birds including ducks, wild turkeys, hawks, jays, eagles, woodpeckers, owls, crows, and bluebirds are spread throughout the region (Ferguson and Hart 1985).

Precipitation and temperature condition the climatologic dynamic in the Zuni area. As Cordell (1984, 1997) emphasizes, annual rainfall and the length of the growing season are among the primary limiting factors for maize agriculture in the American Southwest. Highest amounts of precipitation occur in the mountains, while lowest are found in the western part of the Zuni region. The average annual rainfall at Zuni varies between 279 and 406 mm per year (Crampton 1977; Ferguson and Hart 1985). Despite the low annual rainfall, the Zuni have managed to raise crops such as maize, squash, and beans by dry farming and irrigation over the centuries. They were famous in the nineteenth century for their waffle gardens where they cultivated chili, onions, coriander, amaranth, and other plants.

Cultural Setting

The occupational history of the Zuni region can be summarized as follows: (a) population aggregation during the 13th century; (b) nucleation in larger pueblos on mesa tops in the 14th century; (c) shift to multi-plaza pueblos in river valleys in the 14th and 15th centuries; (d) Spanish colonization in the 16th century; (e) coalescence of the entire Zuni population at Zuni Pueblo after the Pueblo Revolt in the late 17th century; and (f) incorporation of Zuni into Mexican and American political and economic systems in the 19th and 20th centuries (Dublin 1998; Ferguson and Mills 1982, 1987; Saitta 1987; Woodbury 1979).

Cultural Chronology and Settlement Pattern in the Zuni Area

Table 1 summarizes chronological changes in settlement pattern in the Zuni area and, later, at Zuni Pueblo. The Period of Initial Aggregation (A.D. 1175-1275) saw the onset of a pattern that persisted into the Historic Period. This pattern involved a gradual replacement of the small, dispersed villages present at the end of the 12th century by large aggregated pueblos, with multiple room blocks and public architecture (Dublin 1998; Kintigh 1985; Saitta 1987). During the Nucleation Period (A.D. 1275-1400), the process of aggregation intensified. Changes in site configurations are apparent and pueblos became planned with room blocks laid out around a central plaza (Dublin 1998:45; Saitta 1987).

Table 1. Settlement pattern in the Zuni area through time

Time	Period	Settlement pattern
1175-1275	Initial Aggregation	Concentration in large pueblos
1275-1400	**Nucleation**	Planned, nucleated pueblos on mesa tops
1400-1540	**Protohistoric**	Multi-plaza pueblos in floodplains
1540-1821	Spanish	~~Six to seven large Pueblos in the Zuni area~~ Coalescence at Zuni Pueblo in 1692 Formation of satellite villages associated with pastoralism and the cultivation of orchards
1821-1846	Mexican	Year-round occupation at Zuni Pueblo Seasonal occupation of the satellite villages
1846-Present	American	Satellite villages abandoned Formation of large farming villages adjacent to large streams; year-round occupation of the farming villages Farming villages gradually abandoned in Late Historic times due to land restrictions Year-round occupation at Zuni Pueblo

Pueblos built during the early part of this period are generally located at high elevations on mesa tops (Woodbury 1979). By the mid-14th century, a shift in settlement placement occurred, away from canyons and mesas to the broad valleys of the Pescado, Nutria, and Zuni Rivers. These valleys, at elevations of 1,828 to 2,133 meters, provide the most favorable habitation settings in this area (Dozier 1970; Ferguson and Hart 1985:13).

In the Protohistoric Period (A.D. 1400-1540), nucleated pueblos were abandoned, and the settlement pattern shifted to multi-plaza pueblos located in the broad floodplain of the Zuni River Valley. The settlements grew by accretion, or by the addition of new room blocks (Dublin 1998:49). Six or seven large pueblos (some historiographic sources mention eight) were present at the time of Spanish arrival in the area and they continued to be inhabited year-round by the Indians after the Spanish *entrada* (Ferguson and Hart 1985; Kintigh 1990; Mills *et al.* 2003).

The Spanish conquest was accompanied by significant demographic changes, which had a tremendous impact on settlement pattern arrangements. The beginning of the

Spanish colonization period, and especially the 17th century, is characterized by massive abandonment of the pueblos, generally followed by consolidation of the population (Ferguson 1993; Kintigh 1985, 2000). Abandonment is generally understood by scholars to have been a consequence of the massive demographic decline in the years after conquest, driven by factors such as epidemics, labor demands, and intensified conflict with other tribes (Dobyns 1990; Lycett 1995). Recent studies point to the use of long-practiced strategies such as mobility to counteract the pressures brought by the colonial regime (Kullicheck 2003). Consolidation, on the other hand, is regarded as a corollary of the increased conflict with both Spanish and other tribes (Ferguson 1993) or of the application of the Spanish policy of *congregacíon* or *reduccíon* (Deagan 2003; Dublin 1998; Melville 1994). As a result, the settlement landscape was completely reorganized under Spanish governance.

The gradual abandonment of large pueblos culminated with a coalescence of communities at Zuni Pueblo after the Pueblo Revolt. The 18th century is defined by the formation of temporarily-occupied satellite villages housing communities that were politically subordinate to Zuni Pueblo (Dublin 1998; Ferguson 1996; Ferguson and Hart 1985; Kroeber 1917; Spier 1917). These villages were associated with specialized subsistence activities such as sheep herding, the cultivation of orchards, and agriculture. The villages were functional only during the agricultural season from April to October (Ferguson and Mills 1987:247). Accounts taken during Bishop Tamaron's visit to New Mexico in 1760 indicate that a pattern of transhumance associated with pastoralism had already been established in the area (Adams and Chavez 1956; Dublin 1998; Simmons 1979a).

The independence of Mexico in 1821 brought Zuni under the control of the Mexican government. During the Mexican Period (A.D. 1821-1846), the use of seasonal satellite settlements persisted. Ferguson (1993) notes that at least ten satellite villages were temporarily occupied during the Spanish and Mexican periods. Some of the protohistoric pueblos abandoned in the 17th century were reused as sheep camps during these times (Dublin 1998; Ferguson 1993). Archaeological evidence indicates that seasonal villages expanded in the valleys of the Nutria and Pescado Rivers (Dublin 1998; Ferguson 1993; Mills *et al.* 1982).

The year 1846 marks the onset of the American Period in the Zuni area (Dublin 1998; Hart 2003; Simmons 1979a). The American Period at Zuni Pueblo (1846 to present) is characterized by additional major shifts in settlement patterns. In the early years of the American Period, the satellite villages still persisted, but were gradually abandoned and the population became centralized at Zuni Pueblo. During the early 1850s, settlement organization gradually shifted to a pattern similar to that which prevailed under Spanish colonial rule, with a single site occupied year-round and a number of other sites temporarily associated with farming, herding, and defense (Dublin 1998:75). A significant change in settlement pattern occurred in the years after 1850. Specifically, between 1880 and 1930 large river valley farming villages were established near large permanent springs at Upper Nutria, Lower Pescado, and Ojo Caliente. The majority of the population lived in these villages during the farming season (Dublin 1998:77).

During the 20th century, the farming villages were inhabited year-round. Most of the Zuni population lived in outlying villages and returned to Zuni Pueblo primarily for ceremonies. Beginning with the 1930s, the activities at the farming villages were gradually abandoned due to environmental degradation and land use regulations. The residents returned to Zuni Pueblo and, as a result, the pueblo began to undergo a rapid suburban growth.

Architectural History and Settlement Growth at Zuni Pueblo

Historical and archaeological data provide information on the architectural changes that took place at Zuni Pueblo during its 600 years of occupation. Archaeological investigations identified two different settlements, located on both sides of the Zuni River. The two sites are referred to as Halona:wa North and South in the Zuni language (Kroeber 1917). Ceramic analyses indicate that the sites were contemporaneous for at least a short period and establish the earliest occupation date at A.D. 1275-1325 (Ferguson and Mills 1987; Kintigh 1985; Mills *et al.* 2003). The original settlement was probably similar to the planned pueblos, arranged around a plaza, which were characteristic in the area during the 13th and 14th centuries (Ferguson and Mills 1987:244). The architecture changed during Protohistoric times as settlements became permanently occupied (Kintigh 1985). The Spaniards described the pueblos and their architectural style in detail: "the multi-storied stone and adobe complexes of connecting rooms, the plazas and narrow corridors, and the flat mud roofs supported by brush and timbers" (Crampton 1977: 18, 19).

The technological innovations introduced by the Spanish facilitated the construction of larger rooms (Ferguson and Mills 1987). The Catholic Mission, originally constructed in 1629-1630 at the periphery of the village, was later incorporated into a large plaza as new houses were built around it (Ferguson and Hart 1985; Ferguson and Mills 1987). Defensive features were integrated in the architecture of the pueblo during colonial times because of the increased conflict between the Zuni, colonists, and neighboring tribes (Simmons 1979a). After the consolidation of the population at Zuni Pueblo following the Pueblo Revolt, the village expanded substantially. The pueblo grew by accretion as new houses and rooms were added to existing ones. New houses were constructed on the slopes of the hill facing the Zuni River (Ferguson 2003; Ferguson and Hart 1985:74). This architectural plan persisted throughout the 18th and 19th centuries.

In the 19th century, the pueblo, which was the only site occupied year-round, developed into a massive complex of interconnected rooms. Plans of the pueblo illustrate the architectural transformations that took place during historic times. The first plan view of Zuni Pueblo was produced by Mindeleff in 1881 (see Figure 2). Lighter shading indicates successively additional stories. At this time, the pueblo displayed an agglomerative pattern and consisted of seven large blocks of compact multi-storied, terraced houses, arranged around three plazas (Ferguson and Hart 1985:73; Ferguson and Mills 1987:245). Room blocks were either constructed one upon another, forming a succession of terraces, or were added at the edges of the village (Ferguson and Mills:245, 247). The terraces are one of the key architectural features of the 19th century. Topography restricted the lateral expansion into the pueblo core and led to a vertical expansion of up to five terraces in the largest of the room blocks, which encompassed several hundred rooms. The Catholic Mission, which was abandoned at the time, was still located in the center of the largest plaza. The oldest part of the pueblo, around the two small plazas in the northeast maizeer, was the highest and most clustered area.

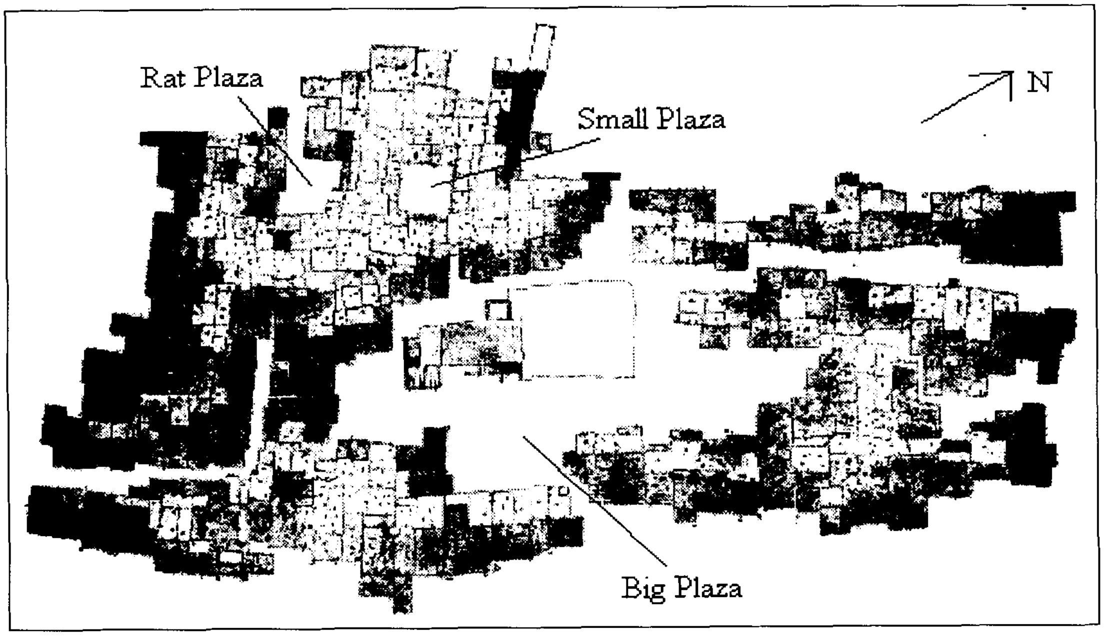

Figure 2. Plan of Zuni Pueblo, by Mindeleff 1881 (picture on CD-Rom used with permission from Jonathan Damp, ZCRE)

This type of architecture was designed to keep outsiders out of the village. Openings into the interior of the pueblo were constricted and house interiors accessed through roof entryways *via* ladders (Ferguson and Hart 1985; Ferguson and Mills 1987) (Figure 3). Terraces were used for outdoor activities such as food preparation, hide tanning, storage, and ceramic manufacture and provided a good vantage for ceremonies that took place in the plazas (Cushing 1920).

The terraces faced east or south for maximum solar exposure and for protection from winds (Ferguson and Hart 1985). Three types of room functions were identified: living, cooking, and storage (Stevenson 1904:292-293). Separate rooms were maintained and used only for ceremonies. Chimneys, constructed from cooking pots, facilitated the venting of smoke from fireplaces. The six kivas, placed on the ground floor of the pueblo, housed different private religious activities (Ferguson and Mills 1987:251). Numerous corrals and waffle gardens surrounded the pueblo.

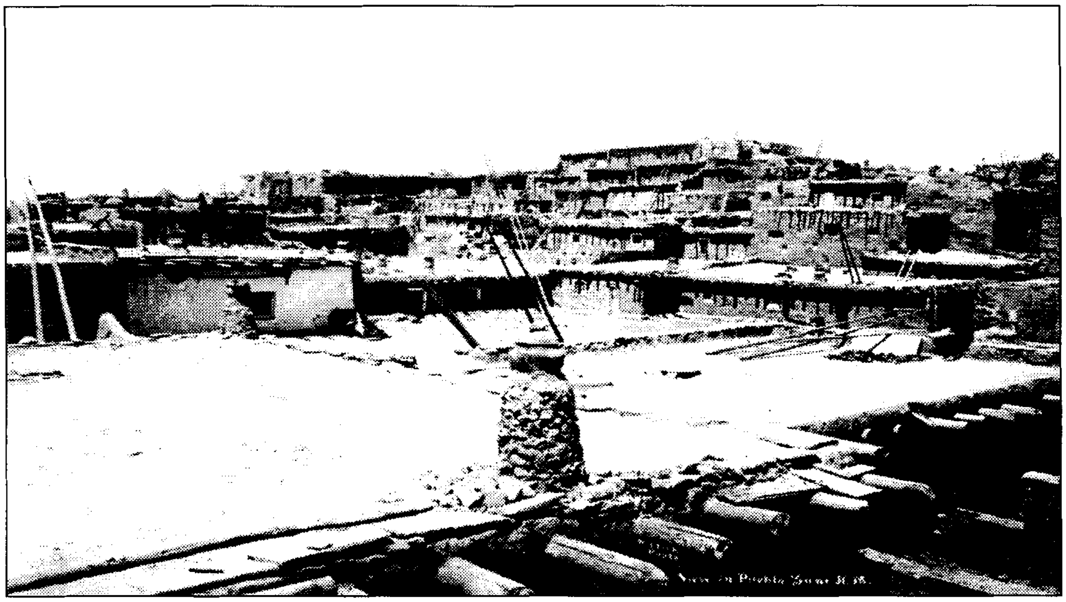

Figure 3. View of the big plaza at Zuni Pueblo in the 1880s. Photograph by John K. Hillers. Smithsonian Institution, National Anthropological Archives.

In the early twentieth century, the pueblo began to undergo extensive architectural alteration accompanied by gradual residential expansion and suburbanization. The construction of the transcontinental railroad to Gallup in 1881 brought, along with an increased involvement of the Zuni in the Anglo-American economic and political system, new construction materials and tools. Consequently, a rapid rebuilding and remodeling of the pueblo commenced. The defensive features were progressively abandoned, as raiding by Navajos and Apaches ceased under new governmental jurisdictions.

The map completed by Kroeber in 1915 shows an architectural shift towards the reduction of upper terraces and the creation of more open space within the pueblo (Ferguson and Mills 1987; Stevenson 1904). The buildings in the old core were reduced to three storeys. In many instances, the lower storeys were abandoned and the rooms filled with trash, construction debris, ash and charcoal, or sand from the river (Bandelier 1970; Ferguson and Mills 1982:113). The streets and alleys inside the pueblo were considerably enlarged and new houses were built outside the area of the original pueblo. Several houses were either reconstructed or built every year. Kroeber (1917) had attributed this process of reconstruction to increased ceremonialism, and particularly to the annual Zuni Shalako ceremony. During this process of creating a more open architectural landscape, one-storied houses gradually replaced the multi- storied ones. The expansion of the pueblo to the southern side of the river accelerated after 1883 when a bridge between the two sides was constructed.

Although the architecture has been dramatically altered since 1881, the old pueblo and its core still maintain the same general plan, with houses clustering around the two small plazas. Traditional aspects, especially those related to religious practices, persist in Zuni architecture. The architectural style of the kivas, the dance plazas, and the religious pathways still preserve their original characteristics. The small plaza in the core of the pueblo remains the most unaltered architectural space. The kivas preserve the old masonry style and retain the roof entryways and ladders. Rooftops continue to be used as viewpoint galleries during ceremonies (Ferguson and Mills 1987:262-263). Current excavations in the old core area of the pueblo show a remarkable conservatism in architectural style during the 600 years of occupation (Howell 2003a:11). The Spanish influence in architecture was minimal, the Zuni maintaining their unique style over centuries. In summary, the last century shows dramatic architectural transformation illustrated in the replacement of the multi-storied room blocks by one-storied houses and the addition of more open spaces within the core of the pueblo.

Economic History

Prior to European influence, the Zuni were self-sufficient and their subsistence was predominantly agricultural. Along with maize, the Zuni cultivated squash, beans, gourds, and sunflower (Dozier 1970; Hammond and Rey 1929; Hodge 1937). They also gathered pinyon nuts, amaizes and greens. The domestic animals kept were dogs and turkeys. Large numbers of turkeys were kept for their feathers rather than for consumption (Hammond and Rey 1966; Hodge 1937; Simmons 1979a). Species hunted by the Zuni included bobcats, coyotes, bears, elk, wild pigs, foxes, deer, mountain sheep, pronghorn antelope, jackrabbit, and cottontail (Crampton 1977; Ferguson and Hart 1985; Hammond and Rey 1929).

The Spanish conquistadors traveled with a "portmanteau biota" that included a variety of Old World cultigens and domestic fauna (Crosby 1986:89; Melville 1994). Among the domestic animals imported were fowl, sheep, goat, pig, cattle, donkey, horse, and mule. Sheep adapted well to the climate, vegetation, and terrain of this area and became the predominant domestic animal during the Historic Period. Imported plants such as grapes, grains such as wheat and barley, and fruit trees and flowers also made their way to the New World. As Melville notes (1994:2), the flourishing of Old World domesticates in the new environments led to a biological conquest as well. In addition to new species, the Spaniards also introduced new technologies and production contexts.

As chroniclers describe, the terrain and the pastures in New Mexico were extremely favorable for livestock grazing (Hammond and Rey 1966:89). However, the timing and rate of incorporation and adoption of domesticated animals by the Zuni is largely unknown (Dublin 1998; Ferguson and Hart 1985; Mills *et al.* 2003:6). Although sheep were sporadically present in the area since Coronado's expedition in 1540 and in larger numbers after Spanish governance was established in 1598, a few decades passed before extensive herding of flocks commenced. Biological data indicate that sheep require up to a decade or more to acclimatize and begin to reproduce in new environments (Grenfell *et al.* 1992). Indeed, when Onate was assigned governor in New Mexico in 1598, it was reported that sheep and cattle were not reproducing well due to the harsh environmental conditions encountered (Baxter 1882).

Major Transitions in Faunal Exploitation in Zuni Area

During the early years of colonization, Spanish pastoralists and, later, the Franciscan missionaries controlled the flocks of sheep and their products. The Missions supported themselves by exporting blankets and knitted stockings made by the Pueblo Indians along with sheep to mining centers in northern Mexico (Webster 2000, 2003). Although the Zuni grazed flocks of sheep for the Missions after the establishment of the Catholic Mission in 1629-1630, no documentary evidence attests to the ownership of sheep at Zuni Pueblo prior to 1721 (Ferguson and Hart 1985; Hart 1995; Minge 1995). Spanish records for the Santa Fe region indicate that in 1639 the Indians kept larger numbers of cattle and sheep than the Spanish (Hackett 1937).

Sheep and goats outnumbered other introduced domesticates by far and rapidly became an important supply of meat and wool in Zuni economy. Large flocks were being bred by the Zuni in 1760 and records mention that the flocks numbered 15,736 sheep by 1779 (Adams and Chavez 1956). The flocks were herded from Zuni Pueblo and the seasonally-occupied villages during the 18th century. By the 19th century the size of flocks doubled and then doubled again by the early 20th century (Ferguson and Hart 1985). Numerous ethnographic and ethnohistoric sources indicate that meat and wool were extracted from the flocks (Crampton 1977; Cushing 1920, 1979; Eggan 1950; Stevenson 1904; Tedlock 1992). Indirect evidence for the increased importance of herding comes from ubiquitous sheep corrals present in the area since Spanish times (Dublin 1998:65).

The increase in flock sizes during the American Period is attributed to reduced conflict and raiding for livestock (Ferguson 1981) and the intensification of trade systems (Eggan and Padney 1979; Ladd 1979b). A case study in the Valley of Mezquital (Melville 1994) documents regulations regarding the exploitation of flocks back to Spanish times. Specifically, restrictions on killing the female stock were imposed because of a decrease in livestock fertility rates related to pasture depreciation. Retention of female lambs in large numbers, a strategy practiced today by agro-pastoralists whose flocks have low fertility rates, results in considerable increases in flock sizes (Munson 2000).

In the 19th century, the Zuni along with the other Western Pueblos, were massively trading woolen textiles (*e.g.*, mantas, kilts, shirts, belts, and cloaks) to the Pueblos in the Rio Grande Valley. However, with the increased involvement in the American cash economy, weaving was gradually abandoned and commercial materials and fabrics replaced wool as raw material. However, the Zuni continued to produce traditional garments that are similar to pre-contact times and are still used in Zuni rituals today (Webster 2003).

The Zuni retained an agro-pastoral economy well into the 20th century. The livestock industry expanded gradually with an increased involvement in trade. The traders established the value of livestock and provided a market for wool. They also introduced the concepts of credit buying and cash (Dublin 1998; Ladd 1979b). The greatest changes in the economy ensued at the end of the 20th century when the agro-pastoral economy was replaced by a wage economy. This shift ultimately led to the incorporation of the Zuni into the American market economic system. Despite the fact that domestic animals probably provide a more reliable source of meat, the Zuni continued to hunt wild game well into the late 19th century (Cushing 1920; Stevenson 1904). Table 2 summarizes current data on Zuni sheep and goats stock from 1779 to 1978.

Table 2. Zuni stock (data from Dublin 1998:84, Table 3.7 and Olsen 1982:417-18, Table 12.15)

Year	Sheep/goats	Horses	Cattle	Burros	Pigs
1779	15,736	N/A	N/A	N/A	N/A
1879	20,000-30,000	310	200	N/A	N/A
1914	58,000	888	695	25	100
1920	40,000	1800	600	No report	No report
1925	35,000	1710	585	30	150
1930	28,600	1300	520	20	200
1934	25,455	730	300	No report	225
1942	25,808	798	788	No report	No report
1947	18,655	1192	813	No report	No report
1952	16,426	800	510	No report	No report
1957	20,156	650	653	No report	No report
1961	18,118	466	804	No report	No report
1972	19,370	400	847	No report	No report
1978	15,874	400	607	No report	No report

In summary, from the time of the Spanish encounter, Zuni subsistence has gradually shifted from a farming-hunting-gathering emphasis to an agro-pastoral one, followed by integration into the modern industrial cash economy. These economic transitions provide important clues for the current zooarchaeological analysis.

Demographic Trends at Zuni Pueblo

Demographic collapse constitutes a major element in the conquest and colonization of the Americas. Along with foods and technologies, the Spaniards also carried with them Old World pathogens. Immunologically defenseless native populations had to face a rapid spread of diseases. Diseases brought to the New World such as smallpox, measles, influenza, plague, and tuberculosis contributed to increased mortality rates among the Pueblo population. In the Zuni area, population decline was amplified by periods of famine associated with droughts and increased conflict with nomadic tribes. Population demographics are also intimately connected with the processes of abandonment and migration that occurred in the area after contact.

Post-contact analyses of Zuni demography and population estimates are included in various sources (*e.g.*, Ferguson 1993; Gutierez 1991; Hodge 1937; Simmons 1979a; Upham 1982). Records and censi of the Bureau of Indian Affairs taken between 1920 and 1972 are summarized in Ladd (1979b). Some of the population estimates are conflicting. Dublin (1998) and Simmons (1979a) present synthetic tables for the Zuni area, as well as for Zuni Pueblo. Table 3 and Figure 4 illustrate the general demographic trajectory at Zuni during Protohistoric and Historic times.

Although the population was subject to periodic epidemics well into the nineteenth century, mortality-driven population decline was most dramatic in the first 150 years after contact (Crosby 1986; Deagan 2003; Dublin 1998; Ferguson and Mills 1982; Upham 1982). Significantly, in the first 60 years after conquest the decline in population was about 70 %. The lack of rain in 1640 and ensuing years of famine, pestilence, and increased raiding by nomadic tribes considerably reduced the Pueblo population (Simmons 1979a:184). Thousands of people died of starvation during the severe drought in the years 1663-1669 (Vivian 1964). Another severe drought, starting in 1777 and continuing in the following summers, led to a migration to the eastern Pueblos (Simmons 1979a). Severe smallpox epidemics in 1780-1781 and 1898-1899 also resulted in great losses among the population (Eggan and Pandey 1979).

Table 3. Zuni area population (data compiled from Dublin 1998:58; Ladd 1979:492; Simmons 1979:221)

Year	Population
1540	9,000
1581	4,372
1604	3,000
1680	2,500
1706	1,506
1749	2,000
1752	1,004
1760	728
1765	1,593
1776	1,617
1777	2,716
1789	2,437
1792	1,937
1805	1,470
1810	1,602
1821	1,597
1849	1,800
1860-1861	1,150
1870	1,530
1880	1,613
1900-1905	1,514
1910	1,640
1920	1,813
1930	1,952
1940	2205
1950	2,922
1960	4,190
1964	5,176
1970	4,952
1970	5,020
1972	5,760
1988	8,929

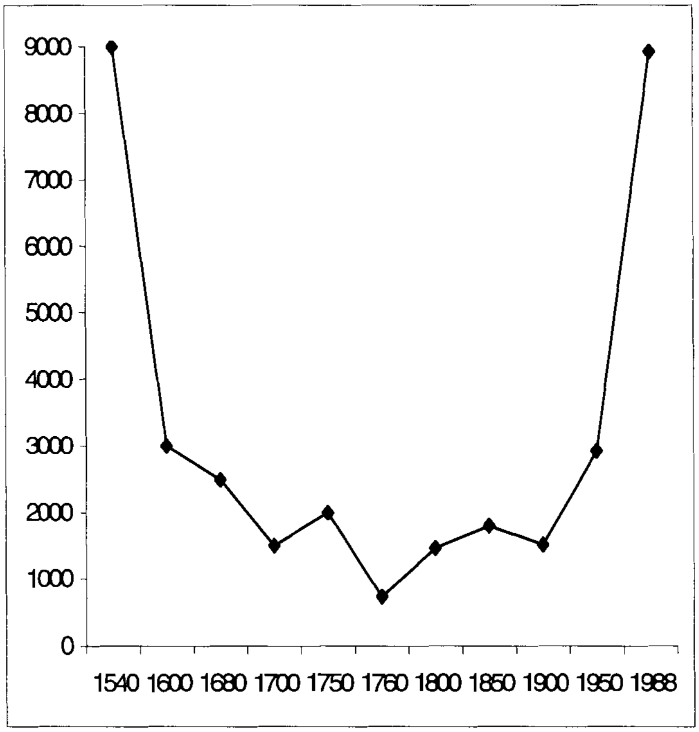

Figure 4. Demographic trends in Zuni area through time

The decline continued through the 17- and 18-th centuries and population reached its lowest numbers in 1760 (Dublin 1998; Simmons 1979a). At the beginning of the 19th century the population was relatively stable but still at low levels. A marked demographic increase occurred at the beginning of the 20th century and, by 1988, the population reached levels similar to those at the time of Contact. Population increased from 1,597 in 1860-1861 to 5,176 in 1974 and to 8,929 in 1988 (Ferguson 1993; Ladd 1979). Fatalities due to epidemics and high infant mortality continued in the 20th century, partly because of Zuni reluctance to accept modern medicine (Dublin 1998; Simmons 1979a).

Research Design

The overall objective of this study is to examine aspects of the transition from a farming/hunting economy to a farming/pastoralist one within the context of Zuni interactions with colonizing societies. The analysis will focus on three major areas: (a) the rate of incorporation and the contribution of Old World domesticates to the Zuni economic system; (b) the structure of sheep flocks and goat herds after their adoption; and (c) the extent to which new technologies were incorporated. Ultimately, this research will provide additional information to studies of colonialism and its impact on indigenous people.

Although zooarchaeological studies have traditionally been used to analyze subsistence practices, there is a growing body of literature that explores the potential of faunal remains to contribute to the understanding of prehistoric social organization and ideology. In the Southwest, Driver (1996), Potter (1997), and Muir and Driver (2002) provide various examples of this. Here, we are mainly concerned with subsistence activity as outlined in the following research questions:

1. When did European-introduced domesticates begin to play an important role in the Zuni economy, and does this support the documentary evidence concerning the use of domesticates?

2. How did the Zuni make use of introduced domesticates? Did they adopt European management practices immediately or was there a transition period? Were domesticates used primarily as a meat source or were other functions (*i.e.*, secondary products) relevant? Can a transition from a mainly meat economy to a primarily cash economy based on wool be detected?

3. How were animals butchered? Were aspects of traditional Zuni butchery techniques retained along with patterns of European butchery techniques?

Theoretical Approach

This dissertation draws on theoretical principles derived from economic and evolutionary biology, optimization models of herd management, and models of colonialism to explore diachronic changes in Zuni subsistence practices.

Evolutionary Biology: Prey Choice Model

Most archaeological applications of foraging theory to the study of faunal remains have borrowed concepts from the prey choice model (*e.g.,* Broughton 1994a, 1994b; Broughton and Grayson 1993; Grayson 1991; Gremillion 2002). While less ambitious than other explanations of faunal variability, the prey choice model provides an explicit framework and offers several advantages for the analysis of changes in foraging patterns through time. As Ugan *et al.* (2003:1315) note, this approach helps identify variables affecting human decisions and the effect these variables have on the temporal and spatial distributions of remains. The prey choice model assumes that the primary goal of foraging is to obtain food calories in the most efficient way. This can be accomplished by either maximizing energetic returns or by minimizing the time needed to meet certain energy requirements (MacArthur and Pianka 1966; Pyke *et al.* 1977; Smith and Winterhalder 1992; Stephens and Krebs 1986; Winterhalder 2001; Winterhalder and Smith 1992). Although the use of energetic returns to predict dietary choices has been criticized because it ignores factors associated with cultural values and nutritional requirements, this approach has proved suitable in many case studies (Smith and Winterhalder 1992; Winterhalder 1981, 2001; Winterhalder and Smith 1991).

The prey choice model ranks the potential prey according to their profitability. Profitability is described in terms of energetic return rates and the costs of pursuing and processing a prey item (Stephens and Krebs 1986). Since the profitability of a prey cannot be directly measured, most studies assume that body size is an apposite proxy measure for evaluating the energetic returns of a species (*e.g.,* Broughton 1994a, 1994b;

Broughton and Grayson 1993). In light of these assumptions, the model predicts that species providing high energetic returns are most profitable and will be selected whenever encountered. Low-ranked species, on the other hand, will be added to the diet as the availability of high-ranked ones declines.

Applications of the prey choice model in archaeology often employ the relationship between diet breadth and foraging efficiency. As predicted by the model (Winterhalder 2001), the introduction of large-bodied species with low search and handling times should result in a narrowing of the diet breadth (*i.e.*, less diverse assemblages), accompanied by a reduction in the use of small-bodied species with higher search and/or handling times. Similarly, if domestic species such as sheep or cattle (which are considered high-ranked resources) are added to the diet, human labour should be preferentially invested in those species that provide highest energy returns and additionally supply secondary products such as power, milk or fleece. As a result, one or more of the low-ranked taxa might be dropped from the diet. As Broughton points out (1994a, 1994b), a diminished use of smaller, less profitable taxa is directly related to the extent to which the addition of high-ranked resources to the diet positively impacts foraging efficiency. In other words, if the addition of high-ranked items does not increase foraging efficiency, no species will be dropped from the diet. Ethnohistoric and ethnographic sources document an increased exploitation of domesticates, especially sheep, after their incorporation into the local Zuni economic system.

The prey choice model is used in the assessment of the distribution of faunal remains through time. A hypothesis relative to the temporal variability expected in the assemblage is that the adoption of Old World domesticates in the Zuni diet produced an increase in foraging efficiency, which in turn, led to a decline in the utilization of low-ranked species (*i.e.*, lagomorphs and turkey). Although wild artiodactyls provide similar amounts of nutrients, the search time is higher, and therefore they should be ranked lower than domesticates. Additionally, sheep provide a source of wool that can be used for the fabrication of blankets. In order to test this hypothesis, the relative abundance of high-ranked resources both wild and domestic, proportional to low-ranked prey items and to indigenous domesticates will be measured. Faunal indices such as the Artiodactyl Index

(Bayham 1979; Szuter and Bayham 1989) provide a useful tool in comparisons between taxa of different body size and will be employed in this study.

Theory of Colonialism and Subsistence Practices

The theory of colonialism incorporates a series of models and concepts to the study of interactions between colonists and Native Americans. An overview of earlier and recent models will be discussed in Chapter 2. The theoretical approach adopted in this research relies on a syncretic/selective model (Cusick 2000; Deagan 1998, 2003; Ewan 2000; Ferguson 1992; Lightfoot and Martinez 1995; Mullins and Paynter 2000). According to this framework, the incorporation of new goods and technologies in colonial settings is selective. Case studies have shown that the adoption and/or persistence of novel foods and culinary practices vary among native peoples facing colonial introductions. Different studies have shown that the choices native people make in colonial settings vary. They can adopt European technologies and foodways while retaining aspects of traditional lifeways, they can reject them, or combine Spanish elements with traditional ones (deFrance 1996, 2003; Gummerman 1997; Leach 1999; Mills *et al.* 2003; Reitz 1985, 1991, 1992a, 1992b, 1993, 1999; Reitz and Scarry 1985; Rogers 1990; Welch and Scarry 1995). Spicer (1961:542) wrote that "Under some circumstances material culture items were replaced or changed rapidly while little else changed, but in other situations social situations and religion changed rapidly while material culture underwent small change". Recent analyses of ceramics and architecture at Zuni Pueblo suggest that some aspects of Zuni traditional practices continued into the late 19th century, while others were quickly modified (Howell 2003a ; Mills *et al.* 2003). Other examples of resistance *versus* acceptance will be discussed in Chapter 2.

This model emphasizes the active role of the Zuni in syncretic processes after the Spanish conquest. This diachronic approach provides a useful context for investigating the selective incorporation of new foods and technologies. Principles related to a persistence of earlier practices such as those connected with local traditions are incorporated in the model. As Reitz (1999:184) points out, although it is sometimes assumed that European domestic animals were rapidly incorporated into local native economies, zooarchaeological examples show that this is not always the case (Reitz 1983, 1991, 1995, 1999; Reitz and Scarry 1985; Reitz and Cumbaa 1983; Reitz and McEwan 1995). Domestic animals were not adopted and incorporated by native people throughout North America. As Reitz argues (1999:193), beside factors related to biological success, cultural factors such as "unfamiliarity with the techniques of animal husbandry, conflicts with traditional plant husbandry practices, depopulation, and social unrest also deterred Native Americans from adopting domestic animals". She further suggests that the adoption of animals is easier in areas where animals could do well without necessitating special care and where the native population had previous farming knowledge. She concludes that:

> Foodways are highly conservative. It is likely that wherever evidence for substantial subsistence change is found, it will be in the context of major alterations in cultural and environmental elements which were even more disruptive than what we know took place in the south-east. The absence of Euro-African plants and animals in these assemblages may also indicate that adopting novel domestic food sources would be a slow and cautious process...The adoption of domestic plants and animals is not to be taken for granted; it occurs where they offer a *clear subsistence advantage.* Native American sites find no single pattern of resource use and little evidence of subsistence change. Subsistence strategies are conservative and not expected to change rapidly under normal circumstances. Even intense interaction with Spanish colonists did not result in fundamental changes. This indicates that European patterns of animal use were not an improvement upon native ones in many colonial environments and may not have been viable in others. It also indicates the strength of pre-Columbian subsistence patterns as well as the degree of cultural change that must accompany changes in subsistence patterns (Reitz 1999: 193-194; emphasis added).

Leach (1999) emphasizes the same idea when discussing the introduction of new crops that subsequently become incorporated into traditional subsistence practices. She points to the role of food processing technologies among other factors in hindering or promoting important subsistence change:

> The brief comparison of the introductions to selected island groups of certain foods that later became staples has shown that three factors operated relatively independently: cultural taste preferences, technological costs, and economic potential. The case has been made that in each of the areas considered, the potato changed its status from just another vegetable...to starch staple, not because of taste preference but because it was technologically undemanding and economically important. For some groups in Britain and Ireland, potatoes allowed the selling of formerly consumed cereals to obtain a small cash income. For other communities it substituted for cereal crops when the people were evicted from land where cereals were viable or were forced

to squat on marginal strips like roadsides and coastlines where cereals could not be grown. In New Zealand, potatoes achieved importance as an item of trade and exchange, rather than a preferred starch staple (Leach 1999:136-137).

Perhaps for such reasons colonial subsistence strategies at Zuni Pueblo were influenced by both indigenous strategies and Iberian foodways. Information on subsistence practices across Iberia and the Canary Islands can be found in different sources (*e.g.,* Bishko 1952; Foster 1960; Ringrose 1996; Simoons 1967; Townsend 1814; Vicens Vives 1969). Sheep, the most widespread economic resource in Spain, were primarily raised for wool (Vicens Vives 1969:517). In addition, fresh meat, milk, and cheese were obtained from the flocks (Melville 1994; Reitz and Cumbaa 1983; Reitz and McEwan 1995). The Spanish raised goats, but in smaller numbers. Although pork and goat meat was more common in the Spanish diet, mutton was a major source of meat. Pigs were herded in small numbers and pork was very expensive, while beef and goat meat were the least costly (Reitz and McEwan 1995; Townsend 1814). In northern Spain, cattle were primarily kept as draft and dairy animals and slaughtered for meat in old age, while in Andalusia large numbers of cattle were raised for beef and hides (Reitz and Cumbaa 1983:155). Young horses and dogs were part of the diet in some areas (Simoons 1967:84, 102). Wild game was not a major component of the Spanish diet (Townsend 1814). Wild hares were hunted by peasants, but deer hunting was restricted to noblemen through royal decrees (Altamira 1949:459; Reitz and Cumbaa 1983). Similar to other area in medieval Europe, meat was more common in the diet of nobles than of peasants.

Reitz and Cumbaa (1983:155) present a hypothesis about faunal assemblage composition that would result from Spanish strategies that is relevant here:

> If this Spanish pattern had been transferred intact to St. Augustine (*and presumably to other sites in the New World where sheep flourished*), the faunal assemblages of St. Augustine would have several distinct characteristics. First, sheep would dominate the diet, followed by cattle and hogs...Domestic fowl, such as chickens, pigeons, and ducks, would be present, as perhaps would be young wild birds. Wild mammals would be extremely rare, as emphasis would have been on domestic food sources purchased from the market (1983:155; emphasis added).

Based on further research, Reitz and Scarry (1985) later refined this hypothesis. The following key attributes of Spanish responses to the new introductions are distinguished as related to domestic animals:

"1) they abandoned traditional resources unsuited to the new environment; 2) they incorporated aboriginal patterns of wild fauna exploitation; 3) they husbanded those Old World domestic animals which could survive with limited attention in the local conditions" (Reitz and Scarry 1985:99).

Herd Management and Population Structure

A pattern of age distribution different from natural attrition in a population may show selection of animals by hunters or farmers for different purposes. Information derived from an analysis of population structure (*i.e.*, age and sex composition of herds) is fundamental to understanding and characterizing human behaviors such as sedentism, mobility, storage, and husbandry strategies. Mortality profiles derived from age distributions are used to infer herd management strategies in the past and to interpret the relative importance of different utilizations of domestic species (Payne 1973).

The two theoretical approaches outlined above (*i.e.*, evolutionary biology and syncretic models) cannot be used to derive expectations about herd management strategies. Instead, models of herd structure will be employed. These models are corroborated with historic and ethnographic sources on Zuni economic emphasis. Payne (1973) and Redding (1981) postulated expected mortality profiles that could result from different utilization of flocks of sheep and goats. A detailed discussion of these models will be presented in Chapter 5. Essentially, the models predict that if animals are raised for meat, most males would be slaughtered by the time they reach optimum weight or slightly earlier, when the growth curve begins to level off (Payne 1973; Redding 1981). A reduced number of animals, mainly females, will be kept alive as reproductive stock. Obtaining secondary products, on the other hand, would result in different patterns of mortality. If milk is the primary objective of the herder, the surplus of lambs and kids (mostly males) will be slaughtered before nine months so they would not compete for milk. If wool becomes the primary purpose, larger number of animals (both sexes) are kept to older age. Most males are castrated and kept as wool-producing wethers (Payne 1973). Problems with the models are that considerations other than energy maximization can dictate herding strategies.

Historic and ethnographic sources attest to the utilization of sheep for meat and wool at Zuni beginning with Mission times and continuing well into Late Historic times (Benedict 1961; Crampton 1977; Cushing 1920; 1979; Eggan 1950; Stevenson 1904; Tedlock 1992; Webster 2000, 2003). However, the patterns of consumption and herd management at Zuni were not documented prior to ethnographies. The Spanish missionaries controlled the flocks of sheep for wool production. Wool was diverted to the pueblos and pueblo-made blankets and other textiles made part of the labor requirements imposed by the Spanish (Hackett 1937; Kelly 1941; Webster 2003). Prior to the Spaniards, the Zuni were using yucca and cotton for their clothing items and blankets (Webster 2003). Although cotton was present at Zuni by the time of the Coronado *entrada,* Spanish accounts indicate that the environment at Zuni was not favorable for growing cotton (Hammond and Rey 1966); therefore, it had to be imported from other pueblos such as Hopi (Hammond and Rey 1940). In this context, the introduction of sheep provided the Zuni with a local supply of wool, which replaced cotton as a fiber source. However, the Zuni continued to trade turquoise for Hopi ceremonial cotton blankets (Webster 2003:25). In the late nineteenth century, Zuni became a major textile producer and exporter. This correlates well with the high increase in flocks described in ethnographic sources.

If sheep were raised for wool and meat at Zuni, the age and sex mortality profile would emphasize both young and adult animals. Part of the surplus of young males not kept as reproductive stock would be culled and part castrated and kept as wool-producing wethers (Payne 1973). If live animals were exported by the Missionaries, then a segment of the sub-adult and adult population, probably the males, could be missing or be less common in the archaeological record. Deviations from this pattern are expected with the increased involvement of the Zuni in commercial markets after the colonial era. Historic and ethnographic examples where wool is an important source of income indicate that stable flock sizes can be maintained by retaining only one-third of the annual lamb crop. Substantial offtake in these systems occurs at either 2-3 months, 6-9 months, and/or 12-15 months (Munson 2000:396). Therefore, an increase in mortality among animals in one of these age ranges might be expected in Late Historic times.

Ethnographic data also indicate that thousands of lambs and sheep were slaughtered during ceremonies each year and that the Zuni were more preoccupied with maintaining their herds for wool than for consumption (Ferguson and Hart 1985). If animals were kept for both meat and secondary products such as wool, the faunal record from Late Historic times may produce remains of animals slaughtered at young ages (prior to attaining their optimum weight gain) as well as of animals of old age. The surplus of annual lambs could be killed on the occasion of Shalako ceremonies, this serving the purpose of maintaining flock security. However, an important point to keep in mind is that the deposition of remains took place over a long span of time and, as a result, interpretations of the patterns must be treated with caution. As Olsen points out (1982:422), the tendency among sheep herders today is to sell lambs, especially males. Sub-adult males would therefore be less common in archaeological materials and animals between 18 and 24 months would be mostly females. Table 4 summarizes the information on the sex composition of sheep stock owned and slaughtered by the Zuni between 1914 and 1934.

Table 4. Stock owned and slaughtered by the Zuni (source: Olsen 1982: 417, 418, Table 12.15)

Year	Rams/Wethers		Ewes		Goats	
	Owned	Slaughtered	Owned	Slaughtered	Owned	Slaughtered
1914	15,000	1,000	35,000	11,500	8,000	0
1915	10,000	1,000	20,000	12,000	6,000	1,500
1917	5,000	2,000	40,000	10,000	6,000	3,000
1923	No report	3,000	No report	9,000	No report	No report
1925	3,000	No report	26,000	No report	6,000	No report
1928	2,500	No report	25,000	No report	1,000	No report
1929	2,500	No report	25,500	No report	1,000	No report
1930	2,100	No report	25,500	No report	1,000	No report
1932	26,330*	2,800*			850	400
1933	27,176*	2,000*			822	No report
1934	25,000*	2,000*			455	40

* Include cumulative data for sheep males, females, and castrates

Butchery and Body-Part Distributions

Butchery and body-part representation have the potential to contribute information on socioeconomic and ethnic differences. As Audoin-Rouzeau (1987:32) points out, butchery and the selection of meat cuts are influenced by "taste, market rules of supply and demand, custom and prejudices, religious precepts, and local tradition". Patterns of differential division and distribution of carcasses at Zuni are examined using descriptions of key attributes of traditional, Spanish-colonial and Anglo-American practices of butchery and body-part distributions from ethnographic, ethnoarchaeological, and archaeological data that will be discussed in Chapter 6.

A pattern of local, household-like consumption is expected in the Middle Village, at Zuni Pueblo. Historic and ethnographic data do not clearly indicate the presence of specialized butchers or a distribution of specific meat cuts in the Zuni market during Spanish or Late Historic Periods. The fact that the Indians provided service and labor for the missions or haciendas during Spanish colonial times implies that they were also doing the butchery, probably under the direction and supervision of the Spanish. An incorporation of Spanish butchery practices might have occurred, but the extent to which this was happening is questionable since general attributes of traditional and Spanish practices are very similar. Consumption and processing at the site would result in a diverse representation of body-parts (Binford and Bertram 1977; Landon 1996). Since sheep was a resource that could be raised locally, we expect representation of a wide range of elements at the site. This might differ for wild artiodactyls (*i.e.,* deer and antelope) for which only a selection of body parts could be brought back from hunting trips to the site.

The increased involvement of the Zuni in markets based on a wool emphasis in Late Historic times is not expected to strongly affect body-part representations either, since information indicates that only wool is distributed. However, the traditional use of certain elements of wild artiodactyls as ceremonial adornments might shift from a discrete to unobservable pattern during the times of Spanish oppression to a more visible one in the assemblage from Late Historic times. In other words, elements of wild artiodactyls used in ceremonies (such as scapulae, ribs, and hoofs) might be found in larger numbers in later times in this area of the pueblo. To conclude, in view of the fact that the Middle Village functioned as the ceremonial core of the pueblo, a conservatism in aspects of traditional Zuni practices that is more significant in this area than in other areas of the site can be expected.

CHAPTER 2
POLITICAL HISTORY AND THEORY OF COLONIALISM

Introduction

The chapter is structured in three sections. The first part outlines the political history of the Zuni area after the Spanish conquest. This is followed by a critical overview of the most prominent theoretical approaches and models for the study of culture change in colonial settings. The chapter concludes with a review of zooarchaeological contributions to Spanish colonialism in New Mexico.

Political History

Castile's colonial expansion across the Atlantic was governed by a series of factors. As Vicens Vives so eloquently writes in his book, *An Economic History of Spain*:

> Perhaps no country but Castile, at the beginning of the 16th century, could have faced up to such an enormous task, and for the following reasons. First, the extraordinary vitality of the 15th-century Castilian; in spite of civil wars, or social disunity, of adverse circumstances, the Castilian of the period shows desires for greatness, perfection, and expansion which are obvious in his political and literary deeds. There was a consciousness of mission that was deeply felt, but whose final objective was unknown. Second, the tension brought about by establishment of an authoritarian, administrative, and centralized government in the country. This abrupt restraint of the Castilian nobles, who had flown so high before Ferdinard and Isabella's reign, made them eager to take part in Spain's great task of discovery. In the third place, the nomadic concept of life ...The nomadic shepherd, the *hidalgo* of the Reconquest, the man who yearned for new horizons, all went to America as a continuation of what they had been doing at home: constantly pressing forward, moving from one place to another. The conquest of America is not the accomplishment of a certain number of famous individuals who explored enormous tracts of land; it is the history of successive Castilian emigrations, of the men who first flocked to the Antilles, then the Isthmus, and then into Mexico and Peru. A fourth factor was the strong craving for material wealth. It must not be believed that the Castilians went to America out of pure missionary urge; the myth of gold shone in the minds of those valiant *hidalgos,* ruined by the great landowners. These people, who had a vital energy which they could not possibly put to work in large-scale business (for which they were not prepared in any case), found an escape value in the gleam of gold and silver, in the dream of riches attained at one fell swoop, either by some lucky stroke or by the acquisition of lands and Indians. Finally, there was the spirit of mission and of justice, for throughout the course of the 15th century there had arisen in Castile a select number of men who felt that their people were linked to an evangelization mission (Vicens Vives 1969:315-316).

A rapid Spanish expansion took place in the New World in search of rich lands after the European discovery of the Americas. Not long after Pizzaro's conquest of the Incas and Cortes' of the Aztec world, the Spaniards were aspiring to even richer lands in the northern country. Their avaricious expeditions were driven by stories such as the medieval legend of the Seven Cities (Crampton 1977; Ferguson and Hart 1985; Simmons 1979a). Spanish travelers wandered across the continent and their accounts included tales of wealthy places north of Mexico, one of which was that of the "Seven Cities of Cibola" (actually the pueblos of the Zuni). Alvar Nuñez Cabeza de Vaca and his three companions were first to provide information about the pueblos in the Rio Grande valley and Zuni area (Bandelier 1890; Crampton 1977; Ferguson and Hart 1985; Hodge and Lewis 1965; Simmons 1979a). During their westward crossing of the American continent, while traveling to Mexico City in 1536, they learned that wealthy agriculturalists resided north of their route in a region that was rich in metals, turquoise, and emeralds. Their reports enthused Viceroy Antonio de Mendoza, who decided to send a party to make a reconnaissance of the legendary Seven Cities. In 1539, Friar Marcos de Niza and Esteban, a former black slave, traveled north of New Spain as far as the Pueblos of the Zuni. He entered the pueblo of Hawikuh, one of southernmost of the Zuni pueblos, occupied for 200 years prior to conquest. Esteban was killed by the Zuni Indians, while Friar Marcos de Niza returned to Mexico with new exaggerated stories about the richness in the Cibola region (Bandelier 1890; Crampton 1977; Hodge 1937; Woodbury 1979). "It was a paradise on earth, and the place I saw was larger than the City of Mexico", Marcos said (Crampton 1977:15). His stories provided an incentive for a major expedition in the Southwest in 1540, under the command of Francisco Vaśquez Coronado. Coronado attempted to conquer Cibola and other regions in the Southwest, including Acoma and Hopi.

The literature documenting the Spanish exploration and conquest of the Pueblo world includes hundreds of titles, but the information is sometimes controversial. Bandelier's work (1890, 1892) constitutes an essential historic source of Cabeza de Vaca's travel, Friar Marcos' preliminary exploration, and of Zuni documentary history up to 1700. Narratives of Cabeza de Vaca and of Pedro de Castañeda, principal chronicler of the Coronado expedition, can be found in Hodge and Lewis (1965). Hammond and Rey (1940) have translated primary documents of the Coronado expedition. Bolton (1949) assembles the most comprehensive study about Coronado's endeavors in the Southwest.

Spanish Conquest and Contact: A.D. 1540-1630

The Coronado expedition established Spain's permanent claim of the Zuni area. Historic accounts indicate that Coronado was accompanied by 300 men and six Franciscan friars, 1,000 horses, 500 cattle, and more than 5000 rams and sheep (Hammond and Rey 1940:278; Mills *et al.* 2003:6; Simmons 1979:178). Coronado attacked and conquered the village of Hawikuh and other pueblos in the Zuni area before proceeding to the Rio Grande valley (Bandelier 1892; Bolton 1949, 1964; Hammond and Rey 1940; Hodge and Lewis 1965; Simmons 1979a; Woodbury 1979). The Pueblos in the Zuni area proved to be barren of wealth and were a disappointment to the Spanish. Not having found any wealth, the Spanish Crown shifted its attention to the pueblos in the Río Grande valley. As a result, the Zunis were spared Spanish influence for almost a century.

Forty years after Coronado's venture, interest in the Zuni area was revived. A new series of explorations and brief Spanish visits were undertaken. The first one was the Rodriguez-Chamuscado Expedition in 1581. It was followed by the expeditions of Antonio Espejo in 1582-1583, and of Oñate in 1598 (Crampton 1977; Dublin 1998; Ferguson and Mills 1982:44; Simmons 1979a; Woodbury 1979). Sixteenth-century expeditions established the onset of Spanish-Indian relations that characterized the remaining colonial era. New Mexico was declared a missionary province of the Franciscan Order in 1598 and European rule was established.

A governorship system and vassalage to the king commenced in New Mexico in 1598 with Juan de Oñate as the first Spanish governor of the province. The governorship continued well into the eighteenth century. Hammond and Rey (1953) put together two volumes of Oñate's accounts of his exploration and colonization of New Mexico. Onate's authority marked the beginning of military, civil, and ecclesiastical control over the Indians. He established his seat at San Juan where he was accompanied by soldiers, friars, colonists, and Mexican Indian servants. He first visited Zuni in 1604 in his attempt to inaugurate missionization in the Southwest but, in truth, to find mineral wealth. Discontent with his policies led to his replacement with another governor in 1607, Pedro de Peralta. In 1610, Santa Fe became the new capital of the province. During the governorship years, the Zuni were pressured by the Spanish colonists to provision the missions and relinquish their own religious beliefs in favor of Catholicism (Simmons 1979a).

Two economic systems were designed by the colonists to extract labor and service from the Indians. An *encomienda* or annual tribute was introduced by Oñate and functioned in New Mexico from 1600 to 1680. During Onate's governorship, *encomenderos* (or proprietors) were sent out from San Juan to collect the *encomienda* from a town or a group of Indians in the form of food and blankets (Crampton 1977; Deagan 2003; Simmons 1979a:182). In turn, the proprietor was expected to provide both material support for the church and military protection for the people from whom he collected the *encomienda.*

Another system used to extract labor from the Pueblo Indians was the *repartimiento.* This was a forced labor system designed to serve the Spanish farms and haciendas. If the Indians did not have maize or wheat to pay their tribute to the governor, they had to work around his household. According to this system, the Indians were supposed to be paid a fixed wage, which did not usually happen.

A permanent Spanish presence in the Zuni area was not documented before the first Missions were built, in 1629 at Hawikuh and 1632 at Halona (present-day Zuni Pueblo) (Bolton 1949; Dublin 1998; Hodge 1937; Woodbury 1979).

Spanish Colonial Period: A.D. 1630-1821

After the governorship system failed to bring the affluence expected by the Crown, proselytism became the primary concern of the Spanish and an intense missionary program was initiated. New Mexico continued to be maintained as a royal colony supported by the crown treasury (Simmons 1979a:181). The province was under the Order of Friars Minor or Franciscans. Western Pueblos, especially Hopi and Zuni were less impacted upon by the Spanish power than Pueblos in the Rio Grande Valley (Adams 1989; Bandelier 1892; Minge 1995; Hammond and Rey 1940, 1953; Hodge 1937). This period is characterized by intense rivalry between the Franciscan clergy and Spanish governors both of whom wanted to exercise authority over the province (Deagan 2003). The *encomienda* and *repartimiento* systems functioned in the province until the Pueblo Revolt in 1680. Missions and large haciendas continued to be constructed by priests and Spanish colonists. This led to tremendous demands for labor and service from the Indians. The Pre-Revolt period was a time of severe droughts and famine and of amplified conflict with the Apache and Navajo peoples.

The Zuni experienced the Spanish influence after the first Catholic Mission was established at Halona in 1632. *Visitas,* or chapels, served by the missionary clergy, were placed at lesser towns such as Matsakya, Kechipbowa, and Kyakima (Crampton 1977; Ferguson and Mills 1982:44: Hodge 1937; Simmons 1979a; Smith *et al.* 1966). During the times of mission colonialism, Franciscan Friars and soldiers moved and lived in the pueblos. The Friars introduced economic changes with the purpose of integrating the Pueblo people into provincial society (Simmons 1979a:181). Among the European traditions brought by the Spanish missionaries included metal tools, new methods of agriculture, new crops, and animal husbandry. The Indians were used as labor to support the clergy. They worked on agricultural and grazing lands at the missions, while the surplus was directed to the profit of the priests (Simmons 1979a:182). As Deagan (2003) points out, in the process of colonization, political, economic, and religious reasons intertwined, even though the declared purpose of colonization was conversion and the propagation of faith.

Pressures upon the Indians were threefold. They were overburdened by demands for conversion from the church, for tribute and labor from colonists, and for civil allegiance from the provincial government. The Friars baptized large numbers of native people and with the intent of converting the entire indigenous population. These excessive attempts for evangelization, augmented by a prohibition of traditional Indian ritual practices, led to acute friction and hostility between the Spanish and Indians. Native resentment over Spanish coercive and repressive measures culminated in 1680 when the pueblos joined to fight against the Spanish regime. For the Pueblo peoples it was a way to regain their political and religious freedom, and a sign of rejection of oppression. Missions at Hawikku and Zuni Pueblo were destroyed and the priests killed (Bandelier 1890; Brugge 1969; Dozier 1970; Ferguson and Hart 1985:59; Hodge 1937; Simmons 1979a). The Zuni took refuge on top of Dowa Yalanne for the next twelve years (Ferguson 1993; Hackett and Shelby 1942). After the Spanish *Reconquista* in 1692, under the command of De Vargas, the Zuni left Dowa Yalanne and consolidated into a single settlement, Zuni Pueblo (Dozier 1970; Ferguson and Mills 1982:45; Simmons 1979a).

Although the mission at Zuni Pueblo was rebuilt, Spanish presence and control were minimal and less obtrusive than previously (Dublin 1998; Simmons 1979a). A new generation of colonists from northern Mexico arrived in the Zuni area. *Encomienda* was not reestablished and the missionary program was less imposing. The large Spanish haciendas were replaced by smaller farms. After 1700 the economic life of the Pueblos improved, agriculture flourished, and the Zuni started to raise large flocks of sheep for their wool (Crampton 1977; Simmons 1979a: 190). By the mid-18th century, Zuni herded over 15,000 sheep from the pueblo and from seasonally-occupied villages (Hart 2003).

The Franciscan Missionary program went defunct in 1820 as a consequence of the perpetual resistance to proselytism and the intensification of Apache and Navajo raids (Crampton 1977; Woodbury 1979:472). During these times, the Zuni assisted as auxiliary troops in the Spanish campaigns against the Apaches and Navajos.

The Spanish Colonial period was a time of severe abuse and repression for the Zuni. It was also a time when aspects of their economic life, religious and political organization suffered adjustments and changes. New tools and technologies, along with Old World species of plants and animals were incorporated into their local economic system. A summary of the cultural changes that distinguish the Spanish era can be found in Dozier (1970:63-71) and Leighton and Adair (1966:20-21).

Mexican Period: A.D. 1821-1846

The Zuni were under the Spanish regime for over 200 years. A shift in sovereignty took place in 1821, with the independence of Mexico. Consequently, the Zuni area came under political control from the Mexican Republic for the next 25 years (Hart 2003; Simmons 1979b). Information on the Mexican Period and the relations between the new government and the Zuni is sparse. The previously secure tribal boundaries established under Spanish rule were gradually dissolved. After 1822, fewer and fewer missionaries served New Mexico. Eventually, the Catholic Mission was abandoned and the clergy withdrew from Zuni Pueblo (Caywood 1972; Dozier 1970; Hart 2003; Simmons 1979b).

Under the Mexicans, the Zuni governed themselves with little or no interference in their religious or political practices (Gutierez 1991; Hall 1989; Hart 2003; Simmons 1979b). There was renewed contact with the Western Pueblos that lasted until the late 19th century. The Mexican regime proved ineffective in maintaining land and water rights among the Indian tribes. This lack of control led to increased violence and discord among tribes in northwestern New Mexico. Factors proposed to account for the increase in conflict and warfare are: (a) collapse of the Spanish control during the final years of Spanish colonial rule; (b) increased importance of livestock as a measure of wealth and intensification of claims over grazing land; and (c) enhanced access to firearms (Crampton 1977; Hart 2003; Simmons 1979b).

As a result, raiding for livestock by Navajos and Apaches deepened, with a marked increase after 1800 (Brugge 1972; Hart 2003; Reeve 1971). Mexican military sporadically assisted the Zuni against Navajo, Apache, and Mexican intrusions (Ferguson and Hart 1985:89). During these times of Mexican expansion and amplified violence among tribes, Zuni settlements were fortified. Throughout the Zuni River Valley, walls and watch towers were erected near agricultural fields.

American Period: A.D. 1846-Present

The year 1846 marked the beginning of the American Period in the Zuni area (Dublin 1998; Hart 2003; Simmons 1979b). The American government' goal was to reduce the conflict among tribes in New Mexico. Measures undertaken by the U.S. government included military campaigns against the nomadic bands and formalization of territorial boundaries by a series of treaties. This period is also characterized by the development of the sphere of contact with Anglo-Americans traders, military personnel, and prospectors who were on their way to California gold fields (Bloom 1936; Curtis 1883; Dozier 1970; Foreman 1941; Green 1990; Hart 2003; Lesley 1929). Consequently, the defensive structures built during the Spanish and Mexican periods were abandoned and the economy flourished. As mentioned in Chapter 1, the small seasonal satellite villages were gradually deserted and large farming villages were constructed near the permanent springs on the Nutria, Ojo Caliente, and Pescado rivers. The farming villages gradually transformed into permanently occupied agricultural centers.

Contact between the Zuni and the U.S. government presence was sporadic during the early years of the American Period. The establishment of Fort Wingate in 1868 near Gallup marked the beginning of a permanent American military presence in the Zuni area. As a result, the Zuni became more involved in trading farm products with the military (Ferguson 1993; Hart 2003; Mills *et al.* 1982). Higher demands for grains and livestock contributed to the expansion of the farming villages between 1870 and 1902. Progressively, the contact between the United States and the Zuni shifted from military to commercial, religious, and educational focus. Areas such as health care, technology, education, and public work improved under American influence.

Land reductions imposed by the American government entailed the establishment of the Zuni reservation in 1877 (Ferguson 1993; Ferguson and Hart 1985; Green 1990; Hart 2003; Ladd 1979b). With the opening of the railroad through Gallup in 1881, trade intensified and Euro-American manufactured goods became accessible to Zuni people. Anglo merchants, who first appeared at Zuni during the 1870s, gradually replaced Mexican traders. After the building of the Santa Fe railway in 1883, American fur-traders had improved access to the Zuni area (Crampton 1977; Hart 2003), which led to the Zuni involvement in a market economy (Dozier 1970; Ladd 1979b; Mills *et al.* 1995). Consequently, economic emphasis shifted toward a more intense exploitation of sheep and cattle products. The flocks doubled by the early 19th century and then doubled again in the early 20th century (Hart 1980).

Access to technological innovations such as wagons, plows, and other farming equipment altered the way in which the Zuni managed their resources (Mills *et al.* 1982:39-41). The construction of the Blackrock Dam between 1904 and 1909 increased available farming land and crop irrigation in the Zuni River Valley.

During the American Period, the economy was based on silversmithing, wage work, herding, and agriculture (Dozier 1970; Ladd 1979a:482). Major economic transformations include the introduction of cash by traders and increased dependence on outside markets. This process contributed to a replacement of the subsistence pattern characteristic of the Spanish and Mexican Periods. Indian traders, along with the concept of credit buying and pawning were all factors that played a major role in this development. Livestock became an important source of income during Late Historic times.

After the Second World War, inadequate land management practices, soil erosion and overgrazing, and increased dependence on the cash economy led to a gradual de-emphasis on farming. This process continued through the 1980s. The large outlying farming villages were abandoned and the population re-inhabited Zuni Pueblo year-round (Dublin 1998; Ladd 1979b).

Theoretical Approaches to Contact and Colonialism - Concepts and Definitions

In the context of cross-cultural models to contact and colonialism, Deagan describes the uniqueness of the Spanish-American experience as follows:

> The Spanish American encounter of 1492 was unparalleled in a number of aspects by other contact situations in known human history. It cannot be characterized by any of the familiar dichotomies – conquerer/conquered, invader/invaded, resident/immigrant, trader/supplier, or European/aboriginal. It was simultaneously an invasion, a colonizing effort, a social experiment, a religious crusade, and an economic enterprise. Unlike most previous Old World or subsequent New World contact, it was both sudden and unexpected, involving two regions of the world that had no prior idea of the other's existence. It was also an encounter of a predominantly literate society with a predominantly nonliterate society, in which the latter group was altered or destroyed with stunning rapidity, thereby severely compromising the evidentiary base for later understanding of contact. Models of culture contact and change derived from other kinds of contact situations have therefore offered limited utility in explaining the trajectory of culture contact in the Spanish Americas after 1492 (Deagan 1998:34).

This section provides a critical overview of the most influential theoretical frameworks for the study of culture contact and change in colonial settings. Approaches to culture contact in the New World can be classified under two major anthropological currents: the "acculturationists" of the 1950s and 1960s and the "quincentennialists" of the 1990s (Deagan 1998). Both currents define culture contact purely in terms of European-Native American relations in the New World. In the volume edited by James G. Cusick (1998), *Studies in Culture Contact. Interactions, Culture Change, and Archaeology*, aspects of contact, conquest, and colonialism in the New World are addressed as a component of the array of cross-cultural historical interactions in colonies (Cusick 1998:1). The volume subsumes different perspectives and theoretical models of contact and change, as well as archaeological case studies around the world.

The study of colonialism retains a central place in Historical Archaeology. Earlier approaches to culture contact underwent substantive changes in the late twentieth century, mostly by research carried out from the Quincentennial. Most culture contact studies of European expansion into the Americas and other parts of the world relied on theoretical frameworks such as "acculturation", world systems and dependency theory, and center-periphery interactions. These theoretical approaches tend to obscure the dynamic, active roles of native peoples in colonial systems. In these models, colonized people are perceived as passive recipients of novel traits, material culture, and institutions from a dominating core (Deagan 1998, 2003; Lightfoot 1995; Lightfoot and Martinez 1995; Rice 1998; Rogers 1993; Stein 1998).

A major trend in historical archaeology is to look at culture contact and change as not being a unidirectional process, in which a dominant European society imposes cultural changes on a subordinate, colonized population (Deagan 1998, 2003; Deagan and Cruxent 1993; Thomas 1991). Recent archaeological studies in Spanish America resort to models of *ethnogenesis* and *creolization, transculturation*, and *syncretism* rather than acculturation, world systems theory, and center-periphery explanations. In parallel, archaeological applications of most recent theoretical approaches concentrate substantially on individual archaeological and historical contexts and the methodologies needed to extract information about culture contact and change from archaeological evidence (Cusick 1998; Deagan 1998:27). Consequently, recent research projects on culture studies include a variety of contexts such as studies of exchange networks, expansion of ancient states, and post-1492 conquest and colonialism in the New World (*e.g.,* case studies in Cusick 1998). Scholars now understand colonialism as a long-term process, in which cultural interactions can be diverse and fall into such categories as conflictual, contesting, accommodating, and adaptive (Cusick 1998; Paynter, 1982, 1985; Wolf 1982). In this type of context, indigenous people may become involved in or reject colonial economic and political milieus. Cusick points out (1998:5) that cultural interactions in the arena of contact do "*not* imply an evolution of interactions over time". Thomas (1991) eloquently emphasizes the fact that there is variation in power relations in colonized places:

> Although the ultimately exploitive character of the global economy can hardly be overlooked, an analysis which makes dominance and extraction central to intersocietal exchange from its beginnings will frequently misconstrue power relations which did not, in fact, entail the subordination of native people. The character of early contact was often such that foreigners were in no position to enforce their demands; consequently, local terms of trade often had to be acceded to; ...the partial intransigence of indigenous societies in the face of both imperialism's sheer violence and its more subtle ploys must be recognized (Thomas 1991:83-84).

Acculturation

Acculturation studies were influential in cultural anthropology since the late 1930s to the 1960s and the concept of acculturation was frequently used to characterize the nature of relationships between Native Americans and Europeans. Acculturation was defined as the process of culture change that occurs "...when groups of individuals having different cultures come into continuous first-hand contact, with subsequent changes in the original cultural patterns of either or both groups" (Redfield *et al.* 1936:149). The basic premise of acculturation models assumes unidirectional material and cultural change imposed by a dominant culture over a conquered one. This ultimately results in the assimilation of smaller, simpler, less powerful societies into a different, superior society and implies the subordination of one group to another. In the contact process, transformations are more significant within the dominated group and ultimately lead to a loss in cultural distinctiveness (Schortman and Urban 1998).

Anthropologists distinguish between acculturation and assimilation. Acculturation refers to the acquisition of cultural traits from a new culture, whereas assimilation refers to a complete absorption of one culture by another (Gordon 1964). Ferraro *et al.* (1994:484-485) define acculturation as a process in which a subordinating culture adopts cultural traits from a dominating one. Acculturation is thus associated with conquest.

Acculturation models have been proposed by Foster (1960) and Spicer (1961). Foster introduced the concept of 'contact' or 'conquest'. This concept incorporates ideas of dynamic interactions between two cultures and the role of human agency, although extremely limited, in the negotiation and integration of new cultural traits. According to Foster (1960:232), indigenous cultures are selective in colonial settings and cultural elements from the donor culture (*e.g.,* Spanish) can be accepted, rejected, or transformed by the recipient culture. These observations are reflected in other works. Lesser (1985:110), for example, wrote that "The changes these community Indians have made over time, taken all in all, seem selective...They chose principally what we call material culture and technology and little of our sentiments and values and our philosophy of life". An example is the phenomenon of resistance among native people to missionization and eradication of traditional Pueblo belief systems. Spicer (1961) also observed that cultural identity persisted in contact contexts even if many aspects of culture changed.

The underlying tenets of acculturation have been questioned by scholars because of their contrast with ethnohistoric and archaeological evidence (*e.g.,* Cusick 1998; Deagan 1998; Lightfoot 1995; Ramenofsky 1995; Rogers 1990, 1993). Common critiques to the concept are that it ignores the role of power relations in contact conditions and, consequently, has limited utility in predicting and interpreting the effects of culture change in such situations (Cusick 1998:126). Examples demonstrate that native people are selective in adopting and incorporating social, political, and economic changes. Consequently, the concept of passive adaptation has been replaced by one in which native people are active agents in making decisions concerning their life (Cusick 1998, 2000; Melville 1994). For example, some researchers point out that resistance, whether passive or active, among native people was a strategy for survival (*e.g.,* Saunders 1998). Recent archaeological applications use refined versions of theories of acculturation (*e.g.,* Rogers 1990, 1993). These studies demonstrate that archaeological studies in general, and studies of material culture in particular, can still benefit from using revised concepts drawn on acculturative models. Acculturation concepts also proved useful in studies of processes of "creolization" (*e.g.*, Deagan 1983).

World Systems Theory

Wallerstein's (1974, 1980) capitalist model has been influential in studies of colonialism on a macro-scale. According to Wallerstein, capitalism results from changes in economic and political relations. Within these sets of conditions, the model postulates the nature of economic and political interactions between the core and periphery. Essentially, the model emphasizes hegemonic aspects of the core-periphery relationship. Economically, the system operates though exchange and trade between these two entities. The core or "the nexus of political and economic centralization" (Rice 1998:45) not only asserts economic monopoly over the peripheries, but it also controls them politically. People at the peripheries provide inexpensive labor and raw materials for the core and depend upon it for political decisions. The core uses the raw materials in manufacturing industries and then sells the finished products back to people in peripheries. As some workers point out, this type of centralized economic exploitation from the core encourages accumulation of surplus, which leads to economic poverty in peripheral areas and profound social inequality between the core and peripheries (Schortman and Urban 1998; Stein 1998:223).

The model was heavily critiqued for the basic *a priori* assumptions on which it rests (*e.g.,* Lightfoot 1995; Lightfoot and Martinez 1995; Rice 1998; Rogers 1993; Stein 1998). As Rice (1998:45-46) notes, "a model as encompassing as Wallerstein's world system virtually invites attack". To summarize, world system theory is criticized because it assumes unidirectional dominance from the core, asymmetric technological, economic, and power relations, with trade as the prime mover in social and economic change (Blanton and Feinman 1984; Hill 1998; Kohl 1987; Saunders 1998; Schneider 1977; Smith 1984; Stein 1998; Wolf 1982). In other words, the core exercises a tremendous technological, economic, and political role in shaping life along its peripheries, while peripheries are portrayed as passive recipients. Examples demonstrate that this is not the case in all situations. As Stein (1998:226) points out, these assumptions fail to take into account the fact that the distance between the core and its peripheries, as well as a pre-existing technological advancement in peripheries, can play a role in defining the type of relations between them. Examples show that power relations in colonial enterprises failed when the colonists had no technological advantages over the colonized (Crosby 1986; Kohl 1987). Additionally, examples from Anatolia and Central Asia show that where colonized people had previously developed advanced technologies (*e.g.,* metallurgy and horse breeding), these spread from peripheries to the core. In other examples, peripheries practiced intensive trade with states, while maintaining their political and economic independence (Edens 1992; Kohl 1987). Furthermore, world system theory underestimates the active role indigenous people at peripheries play in determining the colonial encounter (Ferguson and Whitehead 1992; Schortman and Urban 1998). Parallel critiques emphasize the fact that world system theory and its associated concepts minimize the role of luxury items trade and of specific ideological consequences of contact in regional and local economies (Rice 1998: 46; Schortman and Urban 1998; Schneider 1977; Smith 1984). As Rice (1998) points out, Wallerstein's model provides a basis that can be useful to archaeologists who are trying to reconstruct hierarchies in imperial societies because it incorporates principles of hierarchical dynamics.

Frontiers and Borderlands

In examining contexts in which contact occurred, several scholars have also turned their attention to the so-called physical boundary contexts such as peripheries, frontiers, and borderlands (*e.g.,* Bolton 1921; Cusick 2000; Dublin 1998; Lightfoot and Martinez 1995; Martinez 1994; Rice 1998). The literature includes numerous multidisciplinary attempts to define and distinguish between frontiers, peripheries and boundaries. Recent research emphasizes an active role of peripheries, frontiers, and boundaries as agents of change in contact situations.

Scholars look at frontiers as areas where interactions between groups are intense and lead to rapid and extensive change (Forbes 1968; Paynter 1985; Rice 1998; Wolf 1982). Frontier areas are open systems, characterized by fluid relationships among groups coming into contact (Dublin 1998:14). Both frontiers and borderlands are seen as heterogeneous areas where the exchange of goods and ideas takes place more rapidly and where the impact on native and European lifeways is more readily visible.

Frontier models closely integrate the demographic, economic, political, and technological changes that take place in local contexts of culture contact. They look at the relationships between native people and colonists as being dynamic in nature (Dublin 1998; Rice 1998). Decision-making is not directed only from a core or central polity, but takes place at all levels in the society. Several models of frontiers and frontier change have been developed. Among them are the *territorial-hegemonic* model of imperial expansion (D'Altroy 1992) and the *frontier surplus flow* model (Paynter 1982, 1985). Similar to the core-periphery and world-system models, these models emphasize either a variation in political and economic relations between the core and peripheries or between local ecological conditions and the interests of regional elites, but at a more regional or local level. In these scenarios, native strategies are perceived as consequential.

Another frontier model identifies examples of North American frontiers, among which are insular or agrarian, fur trading, ranching, and mining (Hoover 1992; Steffen 1980). Agrarian frontiers, also called insular, are characterized by economically-diverse activities and long-term types of adaptations and settlements. Because of their distance from the core, they are not continuously tied to or influenced by the core. Therefore, these areas will show more adaptations to local environments and more independent changes (Rice 1998:56). In agrarian frontiers economic production can be dictated by either local subsistence or market concerns (Rice 1998:56). Agrarian frontiers can be small farms or settlement plantations. Fur-trading, ranching, and mining frontiers on the other hand, are short-term, economically-specialized adaptations. They are profit-making enterprises, oriented on extraction of raw goods, and characterized by exploitive economic relations (Rice 1998:57). More recent models (Lightfoot and Martinez 1995) emphasize the role of socio-politico-economic competition and of agency in frontier areas.

An insular frontier model seems more applicable to the Zuni area, which was a periphery (Santa Fe) of a periphery (Mexico City) during the Spanish colonial period in New Mexico. At this distance, most of the strategies developed in the periphery would have been largely independent from the core. During the American Period, the economic and political ties between the periphery and the core were closer due in part to the development of transportation systems. Frontier models provide a better way to understand the relationships between two cultures than world system and acculturation ones. They better explain the nature of interaction and movement of goods and technologies across ethnic and political boundaries.

Cusick (2000:47) provides a definition of borderlands. He notes; "A borderland can be defined as an area that is politically and juridically attached to one nation, province, or empire, but which is under strong economic, cultural, and demographic influences from an adjacent polity". He continues by saying that although this definition applies more to modern United States-Mexico border areas, it can also be applied to colonial borderlands. According to Martinez (1994:6-9), borderlands can be differentiated by the nature and degree of social interactions in these areas. For example, they can be *alienated*, characterized by no social interaction, *coexistent*, when interaction is limited, *interdependent,* in which interactions are cooperative and friendly, and *integrated*, where economies are merged, movement across borders is unrestricted, and the social system is singular. Border areas are areas where the creation of new identities takes place with a blending of languages, traditions, and people (Cusick 2000:47). Settlements in borderlands are similar to those in frontier areas in that they have localized autonomy, military functions, systems of law and order, and factionalism. Borderlands differ from frontiers in that they have specific territorial boundaries, are more prone to legal boundary manipulations, banditry and raiding, and to constant effects of immigration (Cusick 2000:48). As Rice points out (1998:59), "a given area may play different roles at – and for – different times: it may be a boundary during some periods, a frontier at others, or a periphery at still others, depending on the specific, political, or economic context".

Culture Contact Studies in Spanish America

'Contact' and 'Colonialism' are two distinctive concepts. According to Dublin (1998:3), during the time of contact, indigenous people are confronted with novel conditions that only through time might become incorporated and crystallized in local economic and political regimes. As she further observes, the term "contact" is ambiguous in that it sometimes refers to the first moment of encounter, while other times to the nature of the relationships and interactions between Natives and Europeans over longer periods of time. Rice (1998:47) points out the variability in culture contact: "Culture contacts may be brief and sporadic, or they may be sustained and structured".

The key characteristics of colonial systems include expansion of a state level system, territorial expansion and imposition of control, all accompanied by economic and political changes (Dublin 1998:16-17). Territorial expansion involves both demographic and political changes. Under colonial systems and governments, social and political change can also occur through contact with traders and other newcomers. For example, societal complexity may increase under demographic and political pressures, or remain unchanged in response to colonial stresses (Egan 1950). Social and political changes are not solitary results of colonization. Among the most pervasive political, religious, and social attributes of Spanish colonies in the Americas were "the centralization of government and economy under Crown control, monolithic Catholicism, an emphasis on life in towns, and formalized notions of class and race" (Deagan 2003:3).

Economically, Spanish colonialism is characterized by a tributary, merchantile system that functions through the use of native labor, exported raw materials, and imported finished goods (Dublin 1998:21). Alexander (1998) describes colonization as follows:

> Colonization is an extractive process predicated on the removal of resources and labor from subsistence production in the colony and channeling them into the production of resources or cash crops, which are exported and consumed by the system core...The colonizing population frequently adopts methods for co-opting labor that radically transform the economic, political, and social structure of the hinterland, disenfranchising conquered peoples from political and economic decision making and reducing indigenous social and political hierarchies to the level of a peasantry or tribe. The relationship between the colonized and the colonizers is essentially one of unbalanced trade, which in some cases creates a division of labor that fosters periphery dependence on the core (Alexander 1998:482-483).

Early culture contact studies of Spanish American colonies have been largely influenced by the work of cultural anthropologists George Foster and Fernardo Ortíz. In 1940, Fernardo Ortíz, one of the founders of Cuban anthropology, introduced the term *transculturation* to describe variability in cultural responses to colonialism (*e.g.*, disadjustment and readjustment, deculturation, and acculturation) that took place in Cuba (1995:98). As opposed to *acculturation*, *transculturation* sees cultural change in contact settings as a two-way process, characterized by dynamic interactions between the cultures involved.

Contemporary archaeological studies incorporate models of transculturation and selective mutual exchange. This approach is considered more pertinent in an area characterized by mixed cultural and genetic ancestry (Deagan 1998:29). Culture contact and change in the Spanish colonial arena is seen as a macro-process involving "complex, multidirectional transculturation, while approaching the exchange, adoption, rejection, and transformation of specific and distinct cultural elements" (Deagan 1998:28). Following the operational models developed by Foster and Ortíz, case studies have shown that interactions between colonizers and native people vary in colonial settings (*e.g.*, Deagan 1995; Ewen 1991; Rogers 1990). Rogers (1990), expanded on Foster's approach and principles of acculturation in his study of historic Arikara culture change. Although it is generally suggested that new traits are selected based on their perceived utility or rejected if more efficient analogues are already present in the recipient culture, Rogers was able to show that shifts in categories of material culture occur depending on context. For example, Euroamerican artifacts were more readily incorporated by the

Arikara in domestic rather than in ceremonial contexts. The Arikara balanced the economic advantage, while maintaining their cultural identity.

Ethnogenesis, Creolization, and Cultural Syncretism

The concept of *ethnogenesis* gained an important place in American anthropology in recent times. As Deagan (1998:29) points out, ethnogenesis has been used "as an alternative to cladistic, unilineal evolutionary models for understanding change and particularly for the genesis of previously unrecognized *ethnoi* who combine and transform elements of multiple cultural traditions in forms and meanings. This process is far more useful in describing the genesis of *criollo* American culture than are, for example, traditional models that track change in one cultural group as provoked by differential influences from another group".

Another theoretical approach that has gained considerable popularity in recent years is that of 'creolization'. In this framework, the nature of the colonial encounter and interchange between European and Native societies is seen as interactive and dynamic. Interaction between colonists and Native Americans is both a syncretic and selective process (*e.g.,* Cusick 2000; Deagan 1998; Ewan 2000; Ferguson 1992; Lightfoot and Martinez 1995; Mills *et al.* 2003; Mullins and Paynter 2000). The term cultural syncretism generally refers to the combination of different forms of belief or practice and the adoption of new items into local contexts (Cusick 2000). Selectivity results in a survival or propagation of some cultural traits, but not of others (Mills *et al.* 2003). Selected material culture traits are later on reworked and perpetuated.

According to this framework, native people respond to colonialism in different ways: they can accept, resist, or reject novel traits. Archaeologically, the incorporation of new technologies can be seen in the use of metal pots instead of ceramic ones (Mills *et al.* 2003), in the gradual adoption of metal tools (Howell 2003a), or in the incorporation of European domesticates to diet (Reitz 1992, 1995). Change in subsistence practices might indicate a selection of colonial products that offer an advantage over traditional strategies (Reitz 1999:193, 194). Resistance, on the other hand, can be indicated by a disappearance of Spanish motifs or ceramic forms (Adams 1989). Spanish motifs and forms disappeared from Hopi ceramics after the Pueblo Revolt. Other examples show a selective blending of

Spanish and traditional domestic practices. For example, metal pots, although widely available in the 20th century at Zuni, were used for stew preparation mainly during the Shalako ceremonies, while other traditional Zuni practices were maintained throughout the rest of the year (Mills *et al.* 2003). Transcripts of cultural rejection can also be expressed in the architectural style and construction materials preferred (Howell 2003b), practices related to ritual and religious beliefs (Scott 1990). In this context, objects related to ritual practices might become more common in the archaeological record (Singleton 1998).

During the 1990s, creolization was widely used in studies of culture contact and culture change. There is no single definition of creolization. Two popular definitions of creolization are provided by James Deetz and Leland Ferguson. Deetz (1996:213) defines creolization as "the interaction between two cultures to produce an integrated mix which is different from its antecedents". He argues that creolization is more than acculturation, in other words, it is a complex process in which both cultures interplay. Ferguson similarly emphasizes the interactions and exchanges that take place between two cultures coming into contact.

The concept of creolization was first used in studies of African Americans (Ferguson 1992) and then adopted in studies of Spanish Colonial societies (Cusick 2000; Deagan 1983, 1996; Ewen 2000). Archaeological applications of ethnogenesis and creolization concepts incorporate gender studies at household and community levels, especially on the role that Indian women played in the development of the Spanish-American *ladino* society (Deagan 1995; Ewen 1991; McEwan 1991). Other studies focus on the selective changes made by Native Americans. Reitz suggests that the Spanish conquest largely depended upon the ease with which introduced plants and animals adapted and flourished in American environments (Reitz 1985, 1990, 1991, 1992, 1995, 1999; Reitz and McEwan 1995; Reitz and Scarry 1985; Reitz and Cumbaa 1983). Zooarchaeological examples show that the capability of Old World domesticates to acclimatize in various New World environments influenced economically related choices among native people and Spanish. In areas where Old World domesticates flourished, foodways incorporate both native and European subsistence practices to different extents (Reitz 1991, 1995; Reitz and Cumbaa 1983; Reitz and Scarry 1985; Reitz and McEwan

1995). Where the environment did not prove suitable for domesticates such as, for example, in Spanish Florida, native foods continued to be the primary component of diet for both Spanish and Indians (Reitz 1995; 1999). In some cases, differences in diet were related to social status and ethnic affiliations (Reitz and Cumbaa 1983). In other instances, access to domestic meat, a desired dietary item, was restricted to the Missions (Reitz 1995). A zooarchaeological analysis of material from the Gran Quivara Pueblo indicates that native people were increasingly relying on small mammals because hunting and the acquisition of bison meat through inter-pueblo exchange became problematic during Spanish times (Spielman 1989). In summary, the adoption of Old World domesticates implies biological adaptation (*e.g.*, local environmental conditions, parasites, local competitors) and emphasizes the advantage they offer over previous subsistence strategies (Reitz 1992, 1995, 1999).

Historical and archaeological research of Spanish Missions demonstrate a selective attitude of native people toward elements of Catholicism (*e.g.*, Gutiérez 1991; Thomas 1991; Weber 1992). Native and Spanish religious elements are incorporated with Christian Indian ones in burials. Resistance can also be seen in elements of clothing. For example, the men at Zuni Pueblo retained their traditional shoulder blanket, albeit with cloth made of wool (Webster 2003:13).

To summarize, many of the concepts and definitions presented for various approaches overlap. For example, as Ewan (2000) points out, some definitions of creolization incorporate ideas and formulations that are firmly rooted in the anthropological literature of acculturation, transculturation, and syncretism. In this context, Cusick (2000) argues that new theoretical approaches should not be seen as rival paradigms. He notes that "it is possible to conceive of creolization as one among a number of processes -acculturation, cultural syncretism, ethnogenesis – that all pertain to the manipulation of self and, ultimately, group affiliations" (Cusick 2000:47).

After an evaluation of the most prominent theoretical approaches and of current archaeological research on Spanish colonialism, the way that new foods and technologies were incorporated into Zuni daily life will be better analyzed by using a diachronic approach, which treats cultural changes as a two-way enculturative process. Processes of change and continuity in colonial Zuni Pueblo can be better explained in light of a syncretic-selective approach that looks at participation of native people in making decisions to structure their lifeways. Elements of Zuni rejection might be seen in aspects related to traditional ceremonial practices. As Dublin (1998:30) points out, "domestic assemblages may change quite radically, while ceremonial assemblages remain essentially the same". Examples of this sort are numerous in the literature of Spanish colonialism.

Previous Zooarchaeological Research at Zuni Pueblo and in Zuni Area

The first faunal investigations in the Zuni area were conducted on a collection recovered from the ancestral village of Hawikku, one of the six or seven large pueblos present in the Zuni area at the time of contact (Hodge 1937; Smith *et al.* 1966). The analysis presents a list of species that were neither tabulated nor standardized (Smith *et al.* 1966). The small mammals identified include cottontail and jackrabbit, woodrat, prairie dog, pocket gopher, and badger. The game mammals reported are white-tailed and mule deer, pronghorn antelope, bison, grizzly bear, coyote, wolf, and bobcat. The data support the presence of some introduced species, such as horse and domestic goat.

The first zooarchaeological analysis at Zuni Pueblo was part of the Waterline Project (Ferguson and Mills 1982; Olsen 1982). A large number of faunal remains was collected during excavations, but the project budget permitted for only 10 % (5,719 bone fragments) of the assemblage to be analyzed (Ferguson 2003). Despite the lack of temporal control, the analysis documented the presence of 27 species including turtles, eagles, ravens, turkey, rabbits, rodents, coyotes and dogs, deer, antelope, sheep and goat, horse, burros, and cattle. The assemblage enabled the collection of detailed information on butchery patterns and of limited data on population structure (*i.e.*, age and sex). Similarities between butchery patterns of wild and domestic artiodactyls were observed. The results of the study reinforce the ethnographic and historic records on animal utilization at Zuni and provide useful baseline information and a valuable source of comparison for the current research.

Etnier (1997) conducted a diachronic analysis of dietary changes by examining the fauna from Lower Pescado village, one of the large historic farming villages occupied during the American period. The analysis was substantiated by an adequate chronological separation between the prehistoric and historic components. Out of the 8,902 bones recovered from the excavations, 2,321 (26.1%) were assigned to prehistoric deposits, and 4,470 (50.2%) to historic ones. The remaining 2,111 bones (23.7%) came from mixed deposits. The analysis suggests that differences in exploitation patterns between the 14th and 19th centuries are the result of the adoption of European domesticates into Zuni traditional economic systems. The assemblage composition in the Historic Period indicates a drop in the proportions of small animals such as rabbits and turkey, associated with an increase in the proportions of artiodactyls, most of which are domesticates. Sheep and goat are most commonly identified species in the historic faunas. Game, such as deer and pronghorn, are represented in small proportions in each of the chronological sub-assemblages.

CHAPTER 3
METHODOLOGY

Introduction

This chapter will discuss methods used in the analysis of zooarchaeological remains from Zuni Pueblo. The chapter begins with a description of the procedures employed in the collection, identification, description, and quantification of the assemblage. This will be followed by a review of the methods selected for the analysis of the temporal distribution of remains. The methods used for ageing and sexing, body part distributions, and butchery are briefly outlined in this chapter and will be detailed in subsequent chapters.

Faunal Analysis

Excavation and Collection

As outlined in Chapter 1, Zuni Pueblo was founded in the 13th century and is still occupied today. This sustained occupation of the Pueblo over centuries has produced several meters of archaeological deposits. Recent excavations were conducted in the core area of the pueblo or Middle Village between 1997 and 2001 (Howell 2001; Nieto and Howell 2001). Most Zunis consider Middle Village the ceremonial heart of the pueblo. Earlier studies at Zuni Pueblo documented the importance of the two small plazas in the center of the Middle Village (Ferguson 2003; Ferguson and Mills 1985). The excavations were conducted by Zuni Cultural Resource Enterprise (ZCRE) as part of a large-scale architectural renovation project. The deposits recovered include various remains from Pre-contact, Spanish, Mexican, and American periods and provide an opportunity to examine their impact on the Zuni. The earliest occupation date for this area of the pueblo was established through ceramic analysis to A.D. 1275-1325. Approximately 17,000 faunal remains were collected from the excavation units.

Forty-two controlled excavations were conducted in houses and rooms located in the Middle Village area between 1997 and 2001. They occurred mostly to the north, east, and west of the Small Plaza. Some excavation units were located south of the Rat Plaza and other two units northeast of the Mission Church. Excavation plans along with stratigraphic profiles of units that contained the highest amounts of animal bones will be presented in Chapter 4.

Early on in the investigations, one 1x1 m excavation unit was executed for every 10 m of house foundation trench. As the project progressed in a house-by-house fashion, larger units of 1x2 m were excavated (Howell 2003). The sediments were screened through a 1/4-inch or 6 mm mesh. Although small mammal and fish remains have a lower chance of being recovered when using this method (Lyman 1982; Payne 1972; Shaffer and Sanchez 1994), numerous specimens smaller than 6 mm were collected. The first level was not screened in instances when it contained only very recent material. Initial excavations proceeded in 10 cm arbitrary levels, while later units employed 20 cm arbitrary levels. Some of the units were excavated in natural stratigraphic layers.

Identification and Recording

The faunal remains were identified using comparative collections at Simon Fraser University, the University of Puget Sound, and the Burke Museum, University of Washington. Several osteological keys were also employed in the identification and assessment of specimens and in artiodactyl discrimination (*e.g.*, Boessneck *et al.* 1964, 1969; Gilbert *et al.* 1981; Lawrence 1951; Payne 1985; Prummel and Frisch 1986; Schmid 1972). Biometrics were also used for the sheep-goat differentiation (Payne 1969). Because NISP was determined as the appropriate measure of quantification for the analysis, specimens that had been broken during or after excavation were reconstructed prior to identification and recording.

The collection was catalogued using a standardized identification and recording system developed by Driver (1999) for Crow Canyon Archaeological Center. Other fields were added to the system because of the different nature of the analysis for the assemblage from Zuni Pueblo. Up to 16 pieces of information were recorded for the identifiable specimens. In addition to a description of the zoological affiliations and characters, information on various taphonomic processes also was recorded.

The Identifiable Bone database includes records on provenience (*i.e.*, FS number), taxon, class, order, skeletal element, laterality, epiphyseal fusion and fusion stage for long bones, breakage, cultural and natural modifications, sex, length, and cortical thickness. Two separate sub-databases, linked to the Identifiable Bone one, were developed for recording butchery marks and standardized biometrics. For butchered bones, information on anatomic location (*e.g.*, proximal, distal, shaft), location on the bone (*e.g.*, anterior, posterior, medial, lateral, *etc.*), mark type (cut, hack/chop, saw), orientation (transverse, longitudinal, oblique), number of marks, and tool type (knife, cleaver like, ax, saw) were catalogued. Standardized biometrics (using von den Driesch 1976) were taken for specimens that can be used in species identification and sexing. For example, the ratio between two measurements on the distal metacarpal condyle (the antero-posterior width of the external trochlea and the medio-lateral width of the condyle) was calculated in order to discriminate between sheep and goat (Payne 1969:296). Measurements of sheep metacarpals and metatarsals (*e.g.*, greatest length, breadth of the proximal and distal ends, and smallest breadth of the diaphysis) were later used for sex designations. Caprid mandibular eruption and wear stages were catalogued separately using a system devised by Payne (1973).

Taxon and Element.

Throughout the examination, faunal remains were separated into ‘identifiable’ and ‘unidentifiable’ categories. According to Driver (1999), a specimen is considered 'identifiable' only if the skeletal element can be assigned. General categories such as 'long bone' or 'axial' were not employed. Axial elements that were difficult to identify were included in broader categories (*e.g.*, vertebra). Mammal phalanges were not identified to fore- or hind limbs.

As previously mentioned, 'identifiable' specimens are those for which the skeletal element could be confidently determined. The taxonomic attribution of specimens was based on firm morphologic or metric criteria. All identifications were completed by direct comparison with modern skeletons and reference to published osteological guides. Bones were identified to species or genus only after careful examination of different sets of morphological and size criteria.

Less conventional categories such as ‘miscellaneous mammal’ or ‘miscellaneous bird’ were used when the designation of elements to taxon was uncertain. For example, mammal remains that could not be identified to family or subfamily were included in categories such as "small mammal" (smaller than *Lepus americanus*), "medium mammal" (equal to or smaller than *Odocoileus* spp.), and "large mammal" (larger than *Odocoileus* spp.). More specific categories, such as "small carnivore" (smaller than *Canis familiaris*) or "small rodent" (smaller than *Sciurus carolinensis*), were similarly used for non-diagnostic specimens of the order Carnivora or Rodentia. Because both Perissodactyl and Artiodactyl remains were present in the collection, differentiating between ungulate elements was problematic at times. Consequently, some fragments of cranium, long bone shafts, vertebrae, and ribs were catalogued as "large-" or "medium ungulate".

Four families of artiodactyls were expected: Cervidae, Antilocapridae, Suidae, and Bovidae. The discrimination between the medium-sized artiodactyls was complex because of the large number of species, both wild and domestic, present or likely to occur in the assemblage. Two species of deer, pronghorn antelope, and mountain sheep live in the area and three domestic species (sheep, goat, and pig) were introduced. Consequently, many fragments of ribs and vertebrae, along with many unfused long bones, were identified only to "medium artiodactyl" level. Bison is also a component of the fauna in the Southwest that might have occurred in the assemblage. Elements that could not be positively assigned as either bison or cattle were included in the "large artiodactyl" group.

The osteological separation between sheep (*Ovis aries*) and goat (*Capra hircus*) was completed using a number of morphological criteria presented in osteological keys (*e.g.*, Boessneck *et al.* 1964, 1970; Halstead *et al.* 2002; Prummel and Frisch 1986) and biometrics (Payne 1971). Table 5 presents a list of the criteria selected. Specimens were also evaluated against modern skeletons in the comparative collection at Simon Fraser University.

Bird bone fragments that are difficult to identify to species, such as long bone shafts, vertebrae, pelvis, sterna and synsacra, were assigned to the following standardized size categories: "small bird" (smaller than *Turdus migratorius*), "medium bird" (smaller than *Mergus merganser*), and "large bird" (*Mergus merganser*-sized and larger).

Table 5. Criteria used in *Ovis/Capra* discrimination (adapted from Zeder 1991:81)

Bone	Criteria	Reference
Cranium	Shape of sutura parietoccipitalis Shape of sutura frontoparietalis	Prummel and Frisch 1986 Boessneck *et al.* 1964
Horn core	Shape Internal and external structure	Zeder 1991
Mandible	Morphological distinctions between young mandibular teeth (dp4) and adult mandibles and mandibular teeth (P3; P4; lateral mandibular foramen	Payne 1985 Halstead *et al.* 2002
Scapula glenoid	Shape of margo cervicalis Outline of the distal articular surface Shape of the column	Boessneck *et al.* 1964 Boessneck 1969 Prummel and Frisch 1986
Humerus distal	Angle of medial condyle Shape of lateral condyle posterior portion Arch of olecranon fossa	Boessneck *et al.* 1964 Boessneck 1969 Prummel and Frisch 1986
Radius proximal	Sulcus of lateral margin Prominence of the lateral epicondylus Length of the surface of articulation with ulna	Boessneck *et al.* 1964 Boessneck 1969 Prummel and Frisch 1986
Radius distal	Anterior rim of the lateral part of the distal articular surface Shape of articulation with the intermedium carpal	Boessneck *et al.* 1964 Prummel and Frisch 1986
Ulna proximal	Shape of lateral coronoid process Shape of proximal edge of the olecranon	Boessneck *et al.* 1964 Boessneck 1969 Prummel and Frisch 1986
Innominate	Lateral process at the tuber ischiadicum	Boessneck 1969
Femur proximal	Shape of femoral head, angle between femoral head and great trochanter	Boessneck *et al.* 1964 Prummel and Frisch 1986
Metacarpal and Metatarsal	General size and slenderness Relative size of trochlear condyles Aspect of sagittal ridges Ratio of condyle to trochlea (metacarpal only)	Boessneck *et al.* 1964 Boessneck 1969 Payne 1971 Prummel and Frisch 1986
Calcaneus	Shape of articular surface with astragalus Projection of the tuber calcanei Shape of corpus calcanei	Boessneck *et al.* 1964 Boessneck 1969
Astragalus	Aspect of the medial-anterior protuberance Angle of medial articular ridge Shape of distal lateral facet	Boessneck *et al.* 1964 Boessneck 1969
1st Phalanx	Aspect and shape of proximal articular surface including posterior groove Prominence of ligament tubercule on posterior side of proximal end Concavity of posterior side of the body	Boessneck *et al.* 1964 Boessneck 1969
2nd Phalanx	Shape of distal articular surface Condylar angle Volar shape of the condylar surface	Boessneck *et al.* 1964
3rd Phalanx	Shape of the sole surface Shape of processus extensorius	Boessneck *et.al.* 1964 Bossneck 1969

Designations such as “Passeriformes”, “Falconiformes”, or “Strigiformes” include bird bones that could not be identified to family or genus.

Bones difficult to designate to element and taxonomic level were classified as unidentifiable. The system developed for recording the unidentifiable fraction of the assemblage includes information on cultural modifications such as burning, cut marks, and tool manufacture.

Part, Side, and Fusion

The 'part' or portion of the element was recorded for each specimen. Using the standardized recording system (Driver 1999), each specimen was described according to the diagnostic features it displayed. For example, the entries for each limb bone include information about presence, absence, degree of completeness of proximal or distal ends, and portion of diaphysis found. Similarly, vertebrae fragments were described according to presence, absence, or degree of completeness of the centrum, neural arch, or the other processes (*i.e.*, spinous, transverse, zygomatic). Body part correspondence was recorded for each element (*e.g.*, head, axial, forequarter, hindquarter, forefoot, hindfoot, foot). Paired elements were sided whenever possible. Bones that could not be sided such as vertebrae, were coded ‘irrelevant’. Elements that can be sided, but are either too fragmentary or difficult to assess such as phalanges and ribs, were coded ‘unknown’. Information on fusion states was catalogued for long bone ends, vertebral centrum, and ribs when available. Three typical states of fusion were recognized: 'unfused' (epiphysis absent), 'just fused' (epiphysis present but with the cartilage still visible between epiphysis and diaphysis), and 'fused' (epiphysis and diaphysis attached). Additional information about the fusion stage sequences (*i.e.*, 'early fusing', 'middle fusing', and 'late fusing') was included for limb bones.

Breakage Types

Bone fractures can be produced by either cultural activities (*e.g.*, feeding and tool making) or by natural agents (*e.g.*, carnivores, trampling, weathering, and compression of sediments due to overburden weight). In order to determine the nature of taphonomic biases that contributed to assemblage patterning, several breakage types were recorded.

The manual (Driver 1999) describes nine types of breakage, reflecting various natural and cultural processes usually recognized on animal bone. Types of cultural breakages recorded include "artifactual" and "spiral" fractures. "Artifactual fractures" consist of marks resulting from deliberate human activity (*i.e.*, cut marks, ground, or polished fracture surfaces). "Spiral fractures" are commonly a consequence of breakage through torsion or percussion and show a smooth bone surface (Binford 1981). Although spiral fractures are generally believed to result from human activity, natural mechanisms such as trampling or carnivore gnawing can occasionally produce similar fracture patterns in small to medium size mammals (Binford 1981:69-86; Lyman 1994:324).

Carnivores and rodents are sometimes responsible for post-depositional fractures of bones on the ground. These types of breakage are defined as “Carnivore fractures” or “Rodent fractures”. Carnivores can leave macerated fracture surfaces, tooth marks and punctures on the surface while chewing and gnawing bone. They can also break bones by either removing the cancellous epiphyses or by chewing on the diaphysis. Puncture and furrow marks commonly occur on the epiphyses, while pitting and scoring are usually found on the diaphysis (Lyman 1994:325). Rodents extensively gnaw bone, leaving a regular and easily recognizable pattern. In many instances, both rodent and carnivore marks, can obliterate the original breakage pattern.

Other breakage types result from post-depositional processes such as erosion, heat, exposure to sun, air and moisture. They include “Eroded fractures”, “Transverse fractures”, or “Splintered fractures”. “Eroded fractures” mainly result from sand abrasion or extensive exposure to sun, water, or wind. The surface of the fracture is smooth and rounded. These fractures can sometimes obliterate the impact of other agents such as carnivores, rodents, and butchering. “Transverse fractures” are sharp and show a linear break running perpendicular to the long axis of the bone. These types of breakage commonly occur when the bones were intensely exposed to heat through cooking or burning or after bone mineralization has begun. In “Splintered fractures”, bones exhibit a series of transverse fractures, longitudinal fissures and cracks, and flaking of the surface. These types of breakage result from extensive exposure to sun, air, and moisture. “Excavator fractures” occur during excavation, storage or analysis. They display a lighter and cleaner surface than the other types of fractures often called ‘fresh’. The colour of the fracture is different from the rest of the bone and very distinctive. Fractures recorded as "Irregular" do not fall in any of these categories. In this case, the breakage is neither parallel nor perpendicular to the long axis of the bone and displays more of a "zig-zag" appearance.

Bone Modification

As in the case of breakage, both natural and cultural agents are responsible for the alteration of specimens. The types of modification recorded include cultural (*e.g.*, cut marks, artifacts, and burning) and natural alterations (*e.g.*, carnivore damage and root etching). Because weathering, such as cracking and flaking of the bone surface, is minimal in the assemblage, weathering stages were not catalogued.

Some specimens displayed traces of burning to different degrees resulting from carbonization or calcinization. Studies show that the exposure of organic material to relatively short-term, low intensity heat, results in bones turning black. In cases of progressive exposure to intense heat, on the other hand, the bones turn white or gray (Lyman 1994; Shipman *et al.* 1984). Burning was recorded following the burning stages and types of discoloration described in the manual (Driver 1999) and in literature (Brain 1981). Sometimes, the effect of burning was discrete, localized at the ends. This was recorded as localized burning.

A separate sub-database was developed to catalogue butchery marks. This body of raw data was intended to provide insight on the time of adoption of metal tools and on specific butchery techniques and patterns. For butchered bones, the location, type, and orientation of marks were recorded following different systems and examples presented in literature (*e.g.*, Fisher 1995; Landon 1996, 1997; Lyman 1987; Reitz and Scarry 1985; Reitz and Wing 1999). In many instances, cut marks occurred on more than one part of the same element. The identification of cut marks was mainly conducted macroscopically. A few marks were examined microscopically in order to avoid confusion with marks caused by stone tools (*i.e.*, obsidian marks). According to Olsen and Shipman (1988) and Greenfield (2004), impressions left by stone tools are broad and poorly defined. Metal tools, on the other hand, are 'V' shape in cross-section and leave uniform patterns on the bone. The marks left by a metal tool also differ in depth and spacing from the marks left by stone tools. In addition, metal tools produce a cleaner and more even slicing cut.

Quantification

Central measures in quantification are NISP and MNI. Both measures are frequently used to assess the representation of taxa in faunal assemblages. NISP or the number of identified specimens is a type of raw data that counts the total number of bone fragments for a certain species. MNI or the minimum number of individuals, on the other hand, is a derived value that gives an estimate of the minimum number of animals represented in the assemblage. The merits, applicability, and disadvantages of both methods have been widely discussed and debated in the zooarchaeological literature (*e.g.*, Bökönyi 1970; Casteel 1977; Chaplin 1971; Clason 1972; Grayson 1973, 1979, 1984; Klein and Cruz Uribe 1984; Lyman 1982, 1994; Ringrose 1993; Watson 1972, 1979; White 1953). As Landon (1996:140) emphasizes, "[i]n a very general sense, the problems with using either NISP or MNI as a measure of taxonomic abundance are the reverse sides of the same coin".

The main goals of quantification in this study are to examine taxonomic representations, body part distributions, and butchery patterns chronologically. General quantifications (based on NISP) at the most basic level are presented in Chapter 4, including total number of bone fragments in the assemblage, proportions of unidentified bone fragments, number of specimens per species and group, and number of specimens per temporal context.

NISP

The relative proportions of different species in the faunal assemblage from Zuni Pueblo were derived from raw bone counts (*cf.* Grayson 1979). Only specimens that could be confidently identified were counted. NISP counts were used to derive relative frequencies of species that were further employed in diachronic analyses of dietary change and the relative importance of animals to diet, and of butchery practices.

The advantages and drawbacks of the NISP method have been extensively debated elsewhere (see a thorough discussion in Grayson 1979 and Ringrose 1993). As different researchers point out (Casteel 1977; Chaplin 1971; Grayson 1973, 1979; Klein and Cruz-Uribe 1984; O'Connor 2000; Reitz and Wing 1999), a major problem when using raw counts as a measure of taxonomic abundance is that of specimen 'interdependence'. This means that each specimen is recorded and counted as a separate item ignoring the fact that some of the bones could come from the same animal, which can result in over-counting. In addition, raw bone counts present a number of problems resulting from different sources of bias unrelated to species frequency. Since the number of bones in a skeleton differs between species, species with more identifiable number of elements per individual will be over-represented when using NISP (Klein and Cruz-Uribe 1984; Payne 1972; Zeder 1991). Similarly, species that have been subject to fragmentation to a higher degree or have higher recovery rates will be over-represented in the assemblage (Grayson 1973, 1979; Ringrose 1993; Watson 1972, 1979). Cultural practices such as transportation, butchering, meat distribution, cooking, disposal strategies along with non-subsistence practices can also lead to either over- or under-representation of certain elements (Lyman 1994; Reitz and Wing 1999; Zeder 1991).

NISP counts were applied to this study because they provide a good way to measure the relative abundance of taxa in an assemblage containing thousands of specimens and covering a large time span. Additionally, the use of raw counts allow direct comparison with similar faunal studies. In the Zuni assemblage, the different temporal sub-assemblages are sufficiently distinct but not to such an extent as to diminish the problem of interdependence. The problem of interdependence was alleviated by examining additional information that could account for the nature of biases in the assemblage. As Zeder (1991:88) notes, once biases not related to species frequencies are assessed, NISP counts provide the best way of measuring the relative proportions of species. It also provides a good means to measure relative abundance when comparing size categories such as artiodactyls, bovids, or even one group (Uerpmann 1973).

MNE and RR

In an effort to circumvent problems related to differential fragmentation and preservation, NISP counts were not used in the analysis of body-part distributions within the deer-size artiodactyls group. Instead, minimum number of elements (MNE) and recovery rates (RR) were employed (Landon 1996; Lyman 1994; Stiner 1994, 2002). Through the use of MNEs, fragments that could come from the same bone are counted as a single element (Landon 1996:141). Recovery rates, on the other hand, provide a way to express the relationship between the number of elements present and the minimum number of carcasses or individuals.

Although MNE, as NISP, is affected by differences in the number of elements in the body and even within the same body part between species, the analysis of body part distributions for the assemblage from Zuni Pueblo is simplified by the fact that species with very similar number of elements are examined (*e.g.*, sheep, goat, pronghorn, deer). This alleviates problems of differential numeric representation of elements in the body and body regions. Recovery rates are employed to assess taphonomic impact on the assemblage.

MNI

MNI or the minimum number of individuals to account for all skeletal elements attributed to one species is an alternative method to NISP that was introduced by White (1952; 1953). MNI is derived in various ways and permutations of this statistic are discussed by several zooarchaeolgists (*e.g.*, Bökönyi 1969, 1970; Chaplin 1971; Clason 1972; Perkins 1973; Uerpmann 1973; Ziegler 1973). Critiques to this method cover many articles and pages in the zooarchaeological literature (*e.g.*, Bökönyi 1970; Casteel 1977; Chaplin 1971; Clason 1972; Daly 1969; Grayson 1973, 1978, 1984; Klein and Cruz-Uribe 1984; Perkins 1973; Ringrose 1993; Uerpman 1973; Watson 1979). One of the most relevant critiques is that MNI varies as a function of sample size (Clason 1972; Grayson 1981; Perkins 1973; Uerpmann 1973). Data aggregation complicates MNI derivations in analyses of distinct spatial or temporal contexts (Grayson 1973, 1979, 1984; Ringrose 1993). Non-interdependence of elements cannot be clearly demonstrated in archaeological contexts that are temporally and spatially distinct, which makes MNI inappropriate as a measure of abundance for these types of contexts. Furthermore, Watson (1979) emphasized that total MNI estimates from sub-assemblages cannot be used as valid permutations in statistical analyses. Grayson (1984), on the other hand, points out that MNI values can be directly predicted from NISP and therefore are a function of NISP.

When using MNI, species with lower numbers of identified specimens or rare species tend to be over-represented and their relative importance becomes exaggerated when compared to species that are highly identifiable (Casteel 1977; Klein and Cruz-Uribe 1984). As with NISP, MNI does not provide a good measure in analyses of body-part representations.

MNI was not selected in this study because of problems related to aggregation. In the context of the Zuni assemblage, MNI cannot be taken as an adequate approximate of the number of individuals contributing to each temporal sub-assemblage. MNI tends to be inflated when separate MNI estimates are calculated and modified by including age, sex, and size criteria for each context (Landon 1996). Another reason for rejecting this analytical method is that it does not present us with a more accurate reflection of species utilization than NISP counts for chronological deposits that represent large time spans. Additionally, if butchered portions are dispersed through exchange and faunal materials derive from a large number of distinct individuals, MNI estimations of the minimum number of individuals contributing to an assemblage or temporal sub-assemblage become suspect.

Temporal Distribution Analysis

Contingency Analysis

Contingency analysis provides a useful means to statistically test the significance of the variation in taxon frequencies between different chronological sub-assemblages. The contingency analysis used here intends to assess the interdependency between two variables: taxon frequencies and their temporal distribution. This type of analysis was previously employed by Muir (1999) in his examinations of the spatial and temporal variability in the faunal assemblage from Sand Canyon Pueblo.

Generally, contingency analysis randomly compares the observed frequency of items within various categories to their theoretically expected frequencies. The contingency analysis was performed using the 'two-way tables' application in 'SYSTAT' (Wilkinson *et al.* 1992: 640-655). The two-way contingency table provides a useful tool when comparing frequencies of different animal groups among chronological assemblages.

The premises of the analysis involve the derivation of 'expected' (*i.e.*, mean) taxonomic frequencies. For this purpose, data from all temporal contexts are pooled assuming a perfectly uniform distribution of remains. The next step in the analysis consists of calculations of the standardized residuals. Standardized residuals are derived by using a formula that compares expected values to observed frequencies in each of the sub-assemblages. The formula used to calculate standardized residuals is as follows:

$$\textbf{standardized residuals} = (\textbf{observed} - \textbf{expected}) / \sqrt{\textbf{expected}}$$

These calculations generally take into account differences in sample size and allow for direct comparisons between sub-assemblages. A derivation of standardized residuals allows for the identification of major sources of variability in the distribution of remains. The analysis is augmented by the Pearson chi-squared statistic, which measures the statistical significance of the variability in an assemblage (Wilkinson *et al.* 1992:640). In order to measure the degree of association (*i.e.*, the strength of the relationship) between variables, a phi-squared coefficient can be further calculated. This coefficient is a fraction of the chi-square value and the number in the sample (Shennan 1997:115). A coefficient of 1.0 indicates a perfect relationship or an absolute association between the two variables. Alternatively, a coefficient close to 0.0 is obtained when no relationship is present.

Population Structure

Ageing and Sexing Sheep and Goat Bones

The methods of ageing and sexing bones of domesticates have been discussed by many researchers (*e.g.*, Davis 1987; Hesse and Wapnish 1985; O'Connor 2000; Reitz and Wing 1999; Udrescu *et al.* 1999). Generally, the age at death can be determined by analyzing patterns of tooth eruption and tooth wear, epiphyseal fusion, and incremental structures (Chaplin 1971; Davis 1987; Deniz and Payne 1982; Hesse and Wapnish 1985; Payne 1973). Two sets of data were employed for the analysis of fauna from Zuni

Pueblo: (a) tooth eruption and attrition; and (b) epiphyseal fusion. Cementum increment analysis was not applied to this study. Although this method has the potential to provide an accurate means for age estimations and particularly for season of death, relatively little work has been done with tooth incrementation in domestic caprines. The biological basis for cementum increments formation is still poorly understood. A high degree of intra-tooth variation in the types of cementum, related to age, sex, and nutritional history, can result in poor correlations between increment patterns and the known age of animals. A better understanding of the causes and degree of variation behind this process will increase the applicability of the method to zooarchaeological assemblages. In addition, studies have shown a high degree of correlation between the ages suggested by tooth eruption and wear and the analyses of incrementation patterns (Brown and Legge 1992; Landon 1996). Eruption and wear stages for mandibular dentition were recorded following Payne (1987), and Zeder (1991). Maxillar dentition and isolated teeth were not included. The systems used to record tooth eruption and wear patterns and the methods employed in the derivation of caprid mandibular age classes and in the construction of survivorship curves are detailed in Chapter 5.

Sex identifications are an important aspect in analyses of population structure. Along with age data, sex patterns are fundamental to evaluations of hypotheses about herd management strategies. The methodology employed to determine the sex of specimens generally involves morphologic and biometric criteria. Sexing bones in the assemblage from Zuni was problematic. The analysis was hindered by a lack of representative male and female skeletons in the comparative collection. In most cases, identifications had to be based on comparison with published illustrations, an approach that did not prove satisfactory. Secondly, elements that present morphological criteria frequently used in sex discriminations such as horn cores or pelvic bones were too fragmentary or rare to make calculations of sex ratios worthwhile. Overall, morphologic distinctions of sex could not be used on a sufficiently large sample to provide a realistic picture of caprid sex ratios. In retrospect, the immature specimens could also have been measured so as to identify the larger juvenile males. However, immature specimens are difficult to identify to genus, so these measurements were not taken.

The analysis of sex was further complicated by the fact that castrated specimens were expected. In order to assist with sex discriminations, measurements of whole caprid metapodials were taken (*e.g.*, greatest length, breadth of the proximal and distal ends, and smallest breadth of the diaphysis). As with the morphologic analysis, metric data proved too scanty to reveal any information on sex ratios. These problems limit the interpretations of Zuni management practices to examinations of age at death only.

Deer-Size Artiodactyl Butchery and Body-Part Distributions

Both caprid and wild deer-size artiodactyl degree of skeletal completeness, body-part distributions, and butchery patterns were diachronically analyzed and compared for similarities and differences. The methods used for both quantification and analysis of body part distributions and butchery patterns are only briefly described here and will be detailed in Chapter 6.

Body-Part Analysis

The analysis of body-part representations and butchery patterns for the Zuni Pueblo assemblage focuses on medium, deer-size artiodactyls and is mainly based on the derivation of frequencies of skeletal elements and skeletal portions. General body part provenience was recorded in the lab for each element (*e.g.*, skull, mandible, vertebral column, ribs, pelvis, *etc.*). Further in the analysis, elements were grouped into either coarse (*e.g.*, head, axial, upper front, lower front, upper hind, lower hind, and foot) or fine (*e.g.*, distal humerus, proximal femur, anterior scapula) subdivisions. As mentioned earlier in the chapter, minimum number of elements (MNE) and recovery rates (RR) were the measures of quantification selected for the analysis of body part distributions. Both methods provide a better way to deal with problems related to differential fragmentation, usually unaccounted for by NISP. Standardized MNE counts were derived using Stiner (1994:244, Table 9.4). Recovery rates, on the other hand, were derived using formulas presented in Landon (1996:141) and Lyman (1994:256). The degree of disparity in the assemblage was examined using a method developed by O'Connor (2000:72, 73, Tables 7.1. and 7.2). This method emphasizes the distribution of elements and element parts above or below the mean if all elements were evenly distributed across the sample.

Minimum number of elements were used to compute skeletal element and skeletal portion frequencies, while RR only skeletal element frequencies. In order to assess the effect of taphonomic biases, recovery rate percentages were compared to predicted survival rates (Binford 1981). Skeletal element frequencies were mainly employed in assessments of the taphonomic history of the assemblage, while skeletal portion frequencies in diachronic analyses of body part distributions.

Because whole bones did not comprise a substantial portion of the sample, subdivisions by whole elements were not applied. Frequencies of elements, grouped by body portion based on MNE were derived and compared in diachronic analyses. Because of the fragmentary state of the cranial elements along with concerns for interdependency and over-counting, only mandibles were included in the 'head' category. The 'axial' category includes the ribs and vertebrae. Limb elements were subdivided into categories of 'upper front' (including the scapula, humerus, radius, and ulna), 'lower front' (including the carpals and metacarpals), 'upper hind' (including the innominate, femur, and tibia), 'lower hind' (including the tarsals and metatarsals) and 'foot' (including the metapodials and phalanges). Body part distributions were compared to the standard proportions found in a complete skeleton.

Butchery Analysis

The basic approach and criteria used for the identification and analysis of butchery marks will be detailed in Chapter 6. Essentially, butchery techniques were analyzed by computing the frequency (based on NISP counts) of bones with cut marks, an approach commonly used by zooarchaeologists (*e.g.*, Bunn and Kroll 1986; Landon 1996; Lyman, 1977, 1994; Zeder 1991). As Lyman (1994:303) points out, when using frequencies of butchery marks as a quantification method, the researcher should be aware of the fact that a lower proportion of bones will display butchery marks relative to the proportion of bones that have been butchered.

Problems with using frequencies of butchered bones to assess butchery patterns are that butchery marks can sometimes result from unintended, accidental, or incidental butchery activities. In addition, there is a lack of consensus among researchers regarding the ways of identifying, standardizing, and recording cut marks. Consequently, frequencies of butchery marks may be of limited utility and ambiguous indicators of butchery practices (Lyman 1994:301; Lupo and O'Connell 2002). Despite these drawbacks, the method is still intensively used in historical inter-assemblage comparisons (*e.g.*, Landon 1996).

Descriptions of element specific and general butchery patterns based on cut mark frequencies are employed in comparisons of temporal similarities and differences in butchery practices between domestic caprid and wild deer-size artiodactyls. Diachronic analyses of butchery patterns also include computations of element group frequencies. For this purpose, elements were grouped into articulator joints (*cf.* Lyman 1994: 313, Table 8.6) as well as into meat-bearing and non-meat bearing categories (*cf.* Lyman 1994:312, Table 8.5) The major anatomical joints are: shoulder (including the scapula), elbow (including distal humerus, proximal radius, and proximal ulna), wrist (including the distal radius, distal ulna, and proximal metacarpus), hip (including proximal femur and innominate), knee (including the distal femur and proximal tibia), and ankle (including the distal tibia, and proximal metacarpus). Frequencies of cut marks on and around the articular ends were also compared to frequencies of cut marks identified on shafts (*e.g.*, humerus, radius-ulna, femur, and tibia). Meaty limbs include the humerus, radius-ulna, femur, and tibia. Metapodials are included in the non-meaty limb category. Frequency distributions of cut marks in each of these categories were chronologically compared in order to assess variation in butchery practices through time.

CHAPTER 4

ZUNI PUEBLO FAUNA: ASSEMBLAGE COMPOSTION AND TEMPORAL DISTRIBUTION

Introduction

This chapter discusses the faunal assemblage recovered during excavations in the Middle Village of Zuni Pueblo. The chapter is divided in two sections. The first part describes the assemblage composition and compares it with results from a faunal analysis from other parts of the site. This sample was obtained from excavations of the waterline system in Zuni Pueblo and includes materials from a wide range of proveniences and archaeological deposits. Data are presented as relative frequencies (based on NISP raw bone counts). The second section focuses on the diachronic analysis of the faunal remains. The stratigraphy of the excavation in the old core of the pueblo or Middle Village spans approximately 600 years of occupation, from A.D. 1350 to A.D. 1900. The temporal analysis includes only remains that could be chronologically assigned. Quantification and statistical tests used in temporal analyses are relative frequencies of taxa based on raw counts (NISP) and contingency tables. The purpose of contingency analysis is to identify significant and consistent patterns in the temporal distribution of faunal remains.

Assemblage Composition

A total of 16,092 specimens was analyzed, of which 62% were identifiable and 38% unidentifiable. Following Driver (1992), all specimens for which the skeletal element can be determined are considered "identifiable"; all others are "unidentifiable". When compared to prehistoric assemblages where the same criteria have been applied, the Zuni assemblage contains above average proportions of "identifiable" specimens. This is probably related to the lack of trampling and weathering and to the relatively rapid sedimentation rates at the site. Overall, bone preservation is very good and there are high proportions of unfused bones (see discussion in Chapter 5, under population structure). A good representation of axial areas of the skeleton such as the vertebrae, which are most susceptible to destruction by a variety of abiotic and biotic agencies (see discussion in Chapter 6, under body part distributions) was also noted.

As indicated in Table 6a, mammal remains are predominant (97%). Birds are represented by less than 3%, while reptiles are less than 1% of the assemblage. No fish remains were identified. A comparison with the faunal results from Zuni Pueblo Waterline (Olsen 1982) is shown in Table 6b. The slightly higher number of bird remains found in the sample from the Middle Village might be related to the ceremonial function of this area.

Table 6a. Frequency of identified faunal remains from Zuni Pueblo, Middle Village

Class	Common Name	NISP	%
Aves	Birds	263	2.62
Mammalia	Mammals	9,761	97.27
Reptilia	Reptiles	10	0.11
Total		10,034	100.00

Table 6b. Frequency of identified faunal remains from Zuni Pueblo, Waterline

Class	Common Name	NISP	%
Aves	Birds	34	0.59
Mammalia	Mammals	5684	99.38
Reptilia	Reptiles	1	0.03
Total		5719	100.00

Tables 7 and 8 present absolute and relative frequencies of individual bird and mammal remains from the Middle Village area. A detailed list of the faunal remains found in the Waterline Project is shown in Appendix A. At least 16 bird and 25 mammal taxa have been identified in the Middle Village area. Some bird and mammal specimens could not be identified to species and were included in general categories, as discussed in Chapter 3. Identification of a number of bird specimens is difficult because of the large number of potential species and consequently were often assigned to categories such as 'medium bird', 'Passeriformes', 'Falconiformes', *etc.*

Table 7. Frequency of bird (Aves) taxa from Zuni Pueblo, Middle Village

Order	Taxon	Common Name	NISP	% Bird	%All Taxa
Pelecaniformes	*Pelecanus erythrorhynchos*	White Pelican	1	0.38	0.01
Ciconiiformes	*Botaurus lentiginosus*	American Bittern	3	1.15	0.02
Anseriformes	*Anas* spp.	Mallards and relatives	16	6.08	0.15
	Aix sponsa	Wood duck	1	0.38	0.01
Falconiformes	Falconiformes	Vultures,Hawks, Eagles	2	0.76	0.01
	Buteo spp.	Hawks	40	15.21	0.03
	Aquila chrysaetos	Golden Eagle	6	2.28	0.05
	Falco spp.	Falcons	1	0.38	0.01
	Falco sparverius	Sparrow Hawk	16	6.08	0.15
Galliformes	Galliformes	Grouse	1	0.38	0.01
	Meleagris gallopavo	Turkey	64	24.34	0.63
	Gallus domesticus	Domestic Chicken	1	0.38	0.01
Gruiformes	*Fulica Americana*	American Coot	1	0.38	0.01
Strigiformes	Strigiformes	Owls	14	5.32	0.13
	Otus asio	Screech Owl	1	0.38	0.01
	Bubo virginianus	Great Horned Owl	18	6.84	0.17
Caprimulgiformes	*Chordeiles minor*	Common Nighthawk	2	0.76	0.01
Piciformes	Piciformes	Woodpeckers	2	0.76	0.01
	Colaptes auratus	Common Flicker	1	0.38	0.01
Passeriformes	Passeriformes	Perching birds	3	1.15	0.02
	Corvus corax	Raven	19	7.22	0.18
	Pica pica	Magpie	1	0.38	0.01
Charadriiformes		Wader	1	0.38	0.01
Miscellaneous	Large Bird		20	7.60	0.19
	Medium Bird		26	9.89	0.25
	Small Bird		2	0.76	0.01
		Total	263	100	2.62

The same applies to some mammal specimens for which osteological criteria were not detectable. These specimens were included in categories such as ‘medium artiodactyl’, ‘Carnivora’, or ‘small mammal’.

Most of the bird species identified are related to ritual practices and were probably captured for their feathers (Cushing 1920; Ladd 1963; Olsen 1982; Stevenson 1904). Spanish accounts mention that large flocks of turkey were kept in corrals by the Zuni at the time of the Spanish *entrada* (Hammond and Rey 1966; Simmons 1979a). Turkeys were raised predominantly for their feathers rather than for consumption (Cushing 1920:357-358; Schroeder 1979:252). Similarly, hawks and eagles were kept for their feathers. Bird feathers had a variety of purposes including ceremonial adornment, prayer stick attachments, and arrow fletching. According to Cushing (1920:21), golden eagles were kept in cages and both their feathers and down were used as adornment for ceremonial costumes. Crows and ravens were sometimes kept as pets.

The groups of mammals identified include Lagomorphs, Rodents, Carnivores, Perissodactyls, and Artiodactyls (see Table 8). Lagomorphs include the two common genera present in the area, cottontails and jackrabbits. These species are readily separable based on size difference. As was the case in prehistoric sites (Potter 1997), cottontails outnumber jackrabbits, and this seems to be typical for the pinyon-juniper zone in the northern Southwest (Driver 2002; Muir 1999). Rabbits were commonly hunted through communal drives, sometimes involving up to 800 people (Crampton 1977; Cushing 1974). Cottontails and jackrabbits were skewered and roasted over the fire and their pelts were used for blankets and clothing (Cushing 1920:591-594).

Similarly, Rodents include the typical suite of species for this region – prairie dogs, ground squirrels and wood rats in the large size range, and kangaroo rat, gophers and mice in the smaller size range. Beaver remains were found in very small numbers. The Zuni consumed large rodents such as prairie dogs and used wood rat flesh and visceral contents in making broth (Cushing 1920:599-600). Carnivores are dominated by canids (probably domestic dogs), although coyote, fox, bobcat, and bear were also present. Bobcats and dogs were used for consumption or fed to pets and eagles (Olsen 1982).

The species of artiodactyls identified include deer, pronghorn, bighorn sheep, sheep and goat, cattle, and pig. Artiodactyls served different economic and ceremonial purposes. Ethnographers describe the use of artiodactyl products in historic times.

Table 8. Frequency of mammalian taxa from Zuni Pueblo, Middle Village

Order	Taxon	Common name	NISP	% Mammals	% All Taxa
Lagomorpha	Lagomopha	Rabbits and Hares	3	0.03	0.02
	Sylvilagus spp.	Cottontail	884	9.05	8.81
	Lepus spp.	Jackrabbit or Hare	496	5.09	4.94
Rodentia	*Cynomys* spp.	Prairie dog	29	0.29	0.28
	Dipodomys ordii	Kangaroo rat	2	0.02	0.01
	Geomyidae	Pocket gopher	2	0.02	0.01
	Neotoma spp.	Wood rat	57	0.59	0.56
	Sciuridae	Squirrels	2	0.02	0.01
	Spermophilus spp.	Ground squirrel	13	0.13	0.12
	Castor canadensis	Beaver	3	0.03	0.02
	Thomomys spp.	Pocket gopher	4	0.04	0.03
	Muridae	Deer mice, Voles	1	0.01	0.01
	Small rodent	Woodrat or smaller	34	0.35	0.33
Carnivora	*Canis familiaris*	Dog	18	0.18	0.17
	Canis latrans	Coyote	22	0.22	0.21
	Canis spp.	Dog, Wolf, Coyote	201	2.07	2.00
	Urocyon or *Vulpes*	Fox	2	0.02	0.01
	Lynx spp.	Lynx or Bobcat	6	0.06	0.05
	Ursidae	Bears	1	0.01	0.01
	Felidae	Cats	3	0.03	0.02
	Small carnivore	Carnivore smaller than fox	16	0.16	0.15
	Medium carnivore	Fox size or larger	94	0.97	0.93
	Large carnivore	Carnivore larger than wolf	1	0.01	0.01
	Carnivora	Carnivores	7	0.07	0.06
Perissodactyla	*Equus asinus*	Mule/Donkey	19	0.19	0.18
	Equus caballus	Horse	43	0.44	0.42
	Equus spp.	Horse or Mule	16	0.16	0.15
Artiodactyla	*Antilocapra americana*	Pronghorn antelope	202	2.06	2.01
	Odocoileus spp.	Deer	254	2.60	2.53
	Odocoileus hemionus	Mule deer	11	0.11	0.10
	Odocoileus virginianus	White-tail deer	1	0.01	0.01
	Ovis canadensis	Bighorn sheep	1	0.01	0.01
	Ovis aries	Sheep	2252	23.08	22.44
	Capra hircus	Goat	402	4.12	4.00
	Ovis aries/Capra hircus	Sheep or goat	570	5.84	5.68
	Bos taurus	Cattle	66	0.67	0.65
	Sus scrofa	Pig	6	0.06	0.05
	Medium artiodactyl	Deer-size artiodactyls	2891	29.62	28.8
	Large artiodactyl	Cattle-size artiodactyls	14	0.14	0.13

Table 8. Frequency of mammalian taxa from Zuni Pueblo: Middle Village cont'd

Order	Taxon	Common name	NISP	% Mammals	%All Taxa
Miscellaneous	Small mammal	Jackrabbit size or smaller	29	0.29	0.28
	Medium mammal	Deer-size or smaller	379	3.89	3.77
	Large mammal		18	0.18	0.17
	Large ungulate		103	1.07	1.02
	Medium ungulate		575	5.91	5.73
	Ungulate		8	0.08	0.07
		Total	9761	100	97.27

In addition to providing an excellent source of meat, their hides were used for clothing, sinew for sewing, and antlers, horns, and bones for tool manufacture. Deer and sheep scapulae, ribs, and hoofs were drilled and used as rattles during ceremonies (Cushing 1920). Phalanges of artiodactyls were attached to the plastron of turtles with leather strips (Cushing 1920; Stevenson 1904). Pronghorn horns were used as ornamentation during ceremonies; their hides were of poorer quality than those of sheep and deer. Sheep, goat, and cattle meat became an important source of protein during historic times. According to Cushing (1920), sheep were also raised for wool. Pigs were not widespread in Zuni economy and their meat was considered a delicacy (Cushing 1920). Horse and donkey/mule were found in small numbers. Horse meat was dried in strips in the first half of the twentieth century (Roberts 1965:16). Burros were kept as pack animals for the transport of food, wood, and sometimes cages of eagles (Cushing 1920:370).

Artiodactyls make up 77 % of the total mammal assemblage, while lagomorphs contribute 16%. Fewer remains come from other groups such as Perissodactyls (0.90%), Carnivores (4.2%), and Rodents (1.7%) (Table 9 a and b).

Table 9. Frequencies of major mammal groups from Zuni Pueblo: a) Middle Village; b) Waterline

a)

Taxon	NISP	%
Artiodactyla	6670	77
Perissodactyla	78	<1
Carnivora	371	4
Rodentia	147	2
Lagomorpha	1383	16
Total	8649	

b)

Taxon	NISP	%
Artiodactyla	4362	96
Perissodactyla	46	1
Carnivora	59	1
Rodentia	14	< 1
Lagomorpha	43	1
Total	4524	

In the assemblage from Waterline, artiodactyls make up 96 % of the mammal assemblage, while other groups contribute more or less than 1% each. Higher percentages of lagomorphs in the current study probably result from availability of larger samples from pre-Contact deposits.

As one would expect, within the artiodactyl order there is an uneven representation of species. (Grayson 1984). Domestic artiodactyls dominate the sample, and sheep were much more common than goat. Deer and pronghorn are represented in roughly equal proportions. A comparison with the Artiodactyls found in the assemblage from Waterline is shown below (Table 10 a and b).

Table 10. Frequencies of major Artiodactyl groups: a) Middle Village; b) Waterline

a)

Taxon	NISP	%
Pronghorn	202	3
Deer	254	4
Bighorn sheep	1	<1
Domestic sheep	2252	34
Domestic goat	402	6
Either sheep or goat	570	8
Sheep/deer sized artiodactyls	2891	43
Cattle	66	1
Pig	6	<1
Cattle size artiodactyls	14	<1
Total	6658	

b)

Taxon	NISP	%
Pronghorn	41	1
Deer	68	1.5
Bighorn sheep	3	<1
Domestic sheep	71	2
Domestic goat	30	1
Either sheep or goat	1782	40
Indeterminate artiodactyls	2261	50
Cattle	96	2
Pig	10	<1
Cattle / Horse	30	1
Total	4392	

Similar proportions among the main artiodactyl groups are evident in the two assemblages. Due to the more fragmentary nature of the collection from Waterline and of consequential identification problems, more bones were included in the indeterminate *Ovis/Capra* category (Olsen 1982). The indeterminate artiodactyl category in the sample from Waterline comprises sheep/deer size artiodactyls.

Cultural vs. Natural Bone Accumulations

Tables 11 and 12 summarize the evidence for cultural and carnivore modification in the assemblage from the Middle Village area. Specimens display moderate cultural modification in the form of grinding, polishing, burning, breakage, and cut marks. Spiral fractures and cut marks are more frequent for artiodactyls than birds, lagomorphs, and rodents. Impact from carnivore damage is present in the sample, but is not significant. Most obvious are punctures resulting from chewing and gnawing of the epiphyseal ends of long bones.

Table 11. Evidence of cultural modification

Taxon		Spiral fractures		Burning		Cut marks		Ground polished	
	NISP	N	%	N	%	N	%	n	%
Ovis spp.	3225	197	6.10	56	1.73	306	9.48	2	0.06
Odocoileus spp.	267	10	3.74			17	6.36	2	0.74
Antilocapra Americana	202	15	7.42	4	1.97	15	7.38		
Medium artiodactyls	2891	152	5.25	58	2.00	241	8.31	2	0.06
Large artiodactyls	14	1	7.14			3	21.42		
Perrisodactyls	78	4	5.12			9	11.5		
Medium Ungulate	575	19	3.30	13	2.26	61	10.60		
Sylvilagus spp.	884	31	3.50	33	3.73			1	0.11
Lepus spp.	496	18	3.62	11	2.21	5	1.00		
Canis spp.	241	6	2.48	2	0.82	2	0.82		
Lynx spp.	6							1	16.66
Medium carnivore	94	1	3.63			1	1.06		
Castor canadensis	3					1	33.33		
Neotoma spp.	57	1	1.75	1	1.75				
Small mammal	29			4	13.8				
Medium mammal	379	9	2.37	26	6.86	11	2.90	2	0.52
Large mammal	18					3	16.66		
Large ungulate	103					28	27.18		
Meleagris gallopavo	64	3	4.68			1	1.56		
Corvus corax	19					1	1.56		
Falco sparverius	16	1	6.25						
Buteo spp.	40					1	2.50		
Medium bird	26	3	11.5						
Small bird	2	2	100						

Table 12. Evidence of carnivore damage on selected taxa

Taxon	NISP	Carnivore damage N	Carnivore damage %
Medium artiodactyls	2891	56	1.93
Ovis aries	2252	28	1.24
Capra hircus	402	8	1.99
Ovis aries/Capra hircus	570	16	2.8
Odocoileus spp.	267	1	0.37
Antilocapra americana	202	3	1.48
Perissodactyls	78	2	2.56
Medium ungulate	575	7	1.21
Canis spp.	241	6	2.48
Medium mammal	379	4	1.05
Meleagris gallopavo	64	1	1.56
Sylvilagus spp.	884	0	0.00
Lepus spp.	496	0	0.00
Sciuridae	15	0	0.00
Neotoma spp.	57	0	0.00

DNA Ovis/Capra Differentiation

A DNA species identification test was performed on a sample of 12 bones that were morphologically identified as either sheep or goat. The analysis was conducted by Dr. Yang in the Ancient DNA laboratory in the Department of Archaeology at Simon Fraser University. A comparison of the morphological discrimination to the DNA results is shown in Table 13. The DNA analysis confirmed morphological identification in 11 out of 12 cases. One pronghorn innominate fragment was erroneously identified as sheep using morphologic criteria.

Table 13. Comparative morphologic and DNA *Ovis/Capra* differentiation

Chronology	Element	Morphology	DNA
AD 1630-1680	innominate	*Ovis*	Negative
AD 1750-1900	humerus	*Capra*	Positive
After Contact	scapula	*Ovis*	Positive
After Contact	radius	*Capra*	Positive
After Contact	ulna	*Ovis*	Positive
AD 1630-1680	metacarpal	*Ovis*	Positive
After Contact	astragalus	*Ovis*	Positive
After Contact	axis	*Ovis*	Positive
AD 1750-1900	innominate	*Ovis*	Positive
After Contact	metatarsal	*Ovis*	Positive
After Contact	cranium	*Ovis*	Positive
After Contact	innominate	*Ovis*	Positive

Temporal Analysis

Faunal assemblages were dated using ceramic seriation (Scholnik 2003; personal communication) and stratigraphic data (Howell 2001; Nieto and Howell 2001). Approximately 8,706 (89%) mammal bones and 223 (85%) bird bones were assigned to different chronological periods and will be discussed in this analysis. Rough date estimates used as guidelines in this study are presented in Table 14. Specimens that could not be temporally assigned were excluded from the temporal analysis.

Table 14. Chronological date estimates

Date range (A.D.)	Temporal Context
1350-1450	Late Prehistoric
1450-1630	Late Prehistoric/Contact
1630-1680	Mission
1680-1800	Post-Revolt
1800-1900	Late Historic

Temporal Features in Middle Village Area

Forty-two units were excavated in Middle Village between 1997 and 2001 (Howell 2001; Nieto and Howell 2001). Excavations were conducted adjacent to or within houses that surround the Small Plaza and the Rat Plaza (Figure 5). The Small Plaza, located in the center part of the Middle Village, served as the ceremonial heart of the pueblo for the Zuni for centuries prior to Spanish conquest and re-gained its status after the Pueblo Revolt.

Fifteen excavation units lack metal artifacts and have been dated prior to the 1580s. The longest stratigraphic sequence resulted from a unit located west of the Small Plaza (Study unit or SU 99) which contained ceramic deposits dating from A.D. 1275-1375 to the early 18th century.

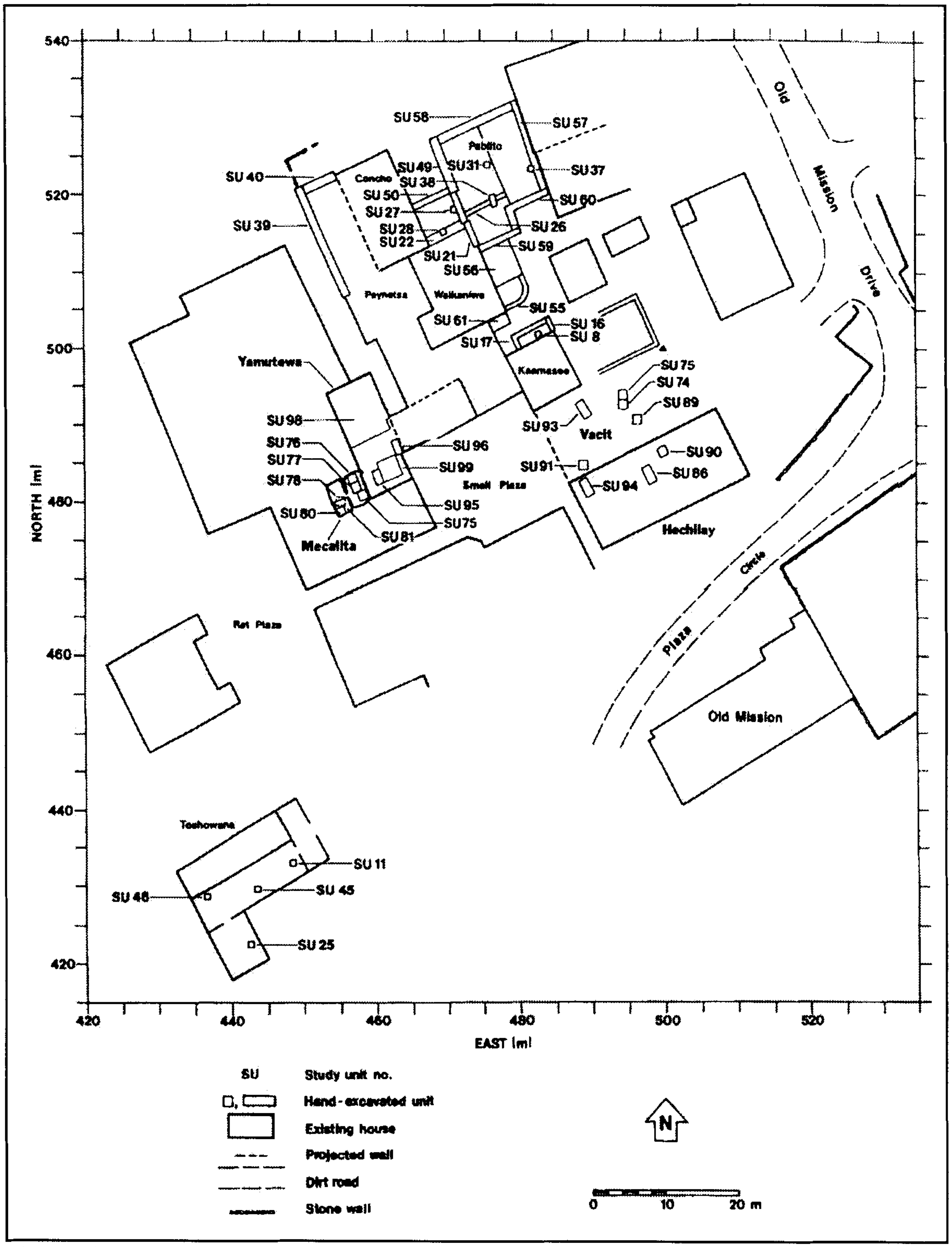

Figure 5. Detail of the oldest portion of the Middle Village, showing units excavated by Zuni Cultural Resource Enterprise (from Mills *et al.* 2003)

Although faunal remains were recovered from a large number of study units (see Appendix B), four of them contained almost 60% of the specimens that could be dated (Table 15). These dated units, excavated within two residences and a court above a previous residence, will be described below.

Table 15. Distribution of faunal remains within selected study units

SU	Mission	Post-Revolt	Late Historic	Total bones
45	1455			1455
46		427	659	1086
86	37	165	1183	1385
93		167	1010	1177

Toshowana Residence

Four 1x1 m units were placed near the walls of the Martha Toshowana residence, located south of the Rat Plaza. The features encountered in these units include a sandstone wall alignment, a partially lined sandstone slab floor, sandstone slabs, an area of white clay, several burned sandstone rocks, a plastered sandstone wall, and an ash pit. Two activity areas, a birthing area and a room interior were also uncovered in this residence. One unit was believed to be a room interior, but no evidence of a floor was found. Sub-floor auger tests were conducted in all study units in order to collect bulk soil samples. This residence includes two units that will be described below.

~~Study Unit 45~~

Study unit 45 was placed within Toshowana residence, next to its southern wall. Although initially believed to be a room interior, no evidence of a floor was found. The unit was excavated in 10-cm arbitrary levels, up to a total of 18 levels. A sandstone wall alignment which extended beyond the unit perimeter was exposed in SU 45 and labeled as Feature 20 (Figure 6a). The orientation was northeast to southwest and the wall measured 1.06 m in length and 1.75 m in height.

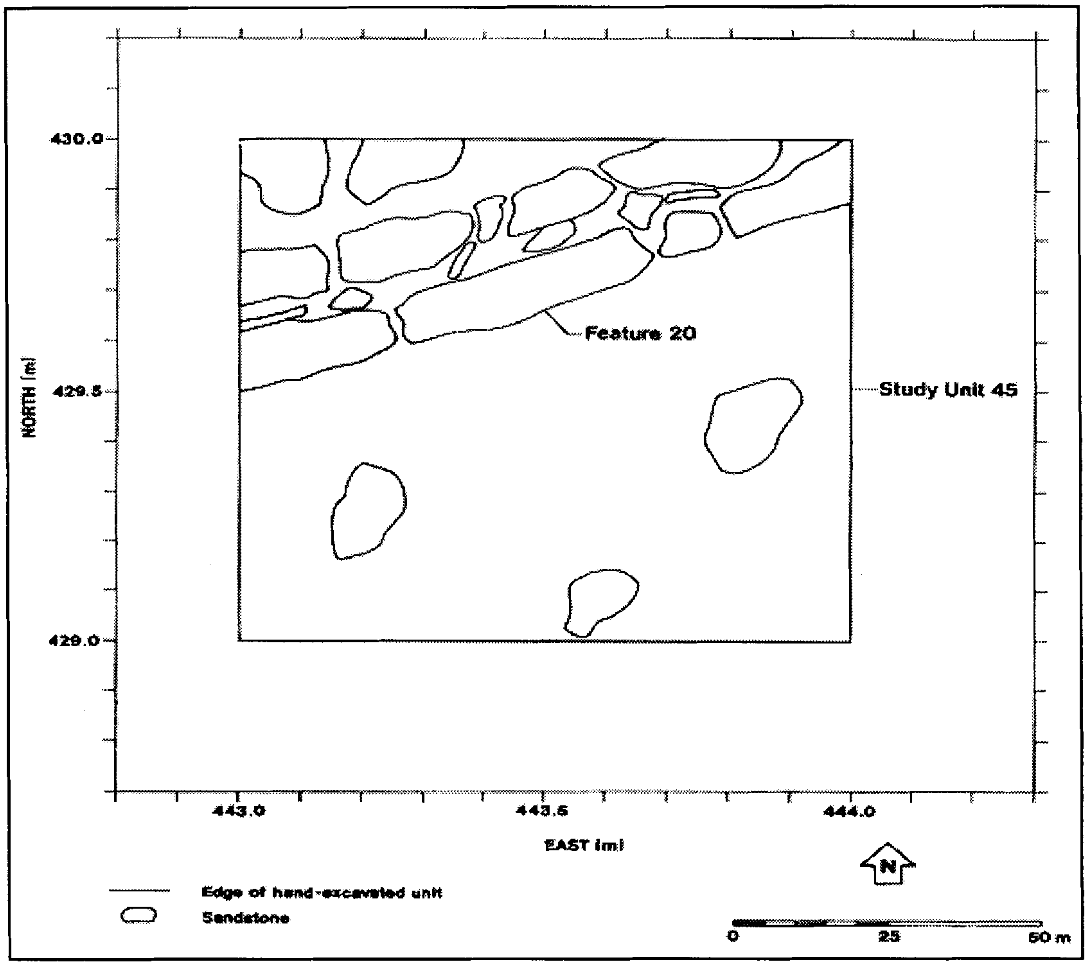

Figure 6a. Plan view of Feature 20 within level 1 of Unit 45 (from Nieto and Howell 2001:15, figure 9)

A possible entryway to another room was uncovered in the northwestern part of the sandstone wall (Figure 6b). The fill of this unit included large amounts of ash, bark, wood chips, and charcoal, and a moderate amount of cultural material. Because of the high amounts of ash, bark, wood chips, and charcoal, the unit was classified as a depositional trash area.

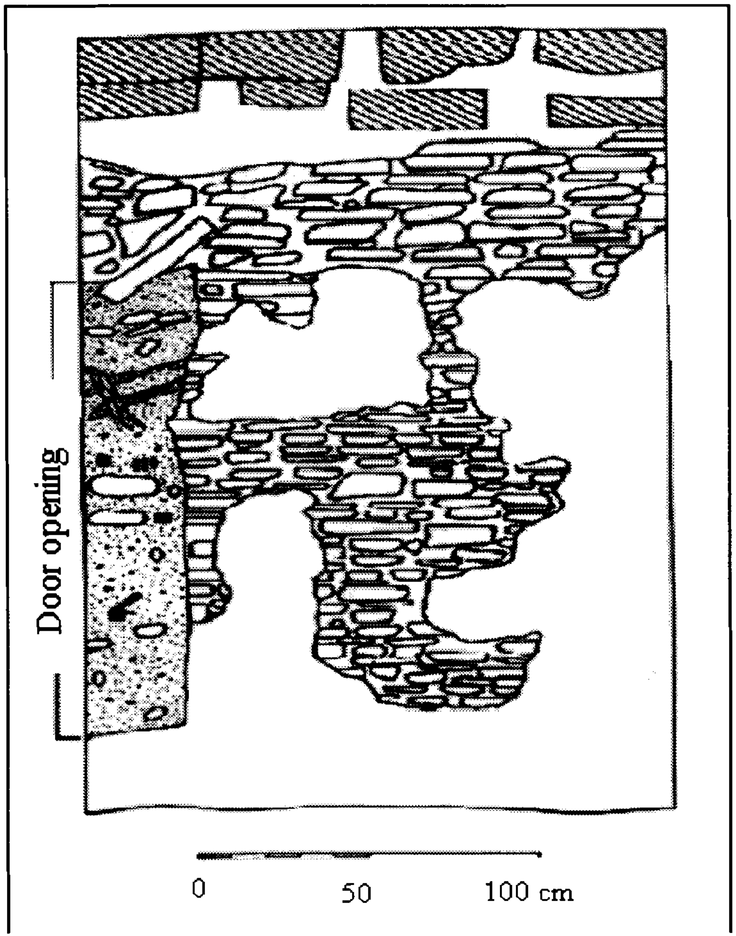

Figure 6b. North wall profile of Unit 45 showing a door opening on the sandstone wall (Feature 20) (from Nieto and Howell 2001:16, figure 10)

Study Unit 46

Study unit 46 was excavated within the same residence, on its northwestern side. A total of twenty 10-cm arbitrary levels were excavated. Among the features discovered was an irregular ash pit, covering almost a third part of the unit. One of its edges was located near the northwest corner of the unit. Two beams that might have been part of a roof were also exposed while excavating the base of the unit, but no floor was encountered. The fill included cultural material, ash, charcoal, and adobe clods. According to the archaeologists, the area might have been purposely filled prior to the building of the current residence (Howell 2001).

Hechilay Residence

The Hechilay residence is located adjacent to the Small Plaza, on its east corner, and south of the Vacit residence (Figure 7). Some interior walls and all flooring had been removed in this house before its demolition and rebuilding. Six units were placed within this residence. Among major features uncovered in the Hechilay house are two crossing walls, one of which is associated with a cinder block, old and recent sandstone masonry and adobe bricks walls, and a slab-lined floor. A metal artifact was found on the floor. A recent wall runs east-west, while two earlier ones run perpendicular on each other.

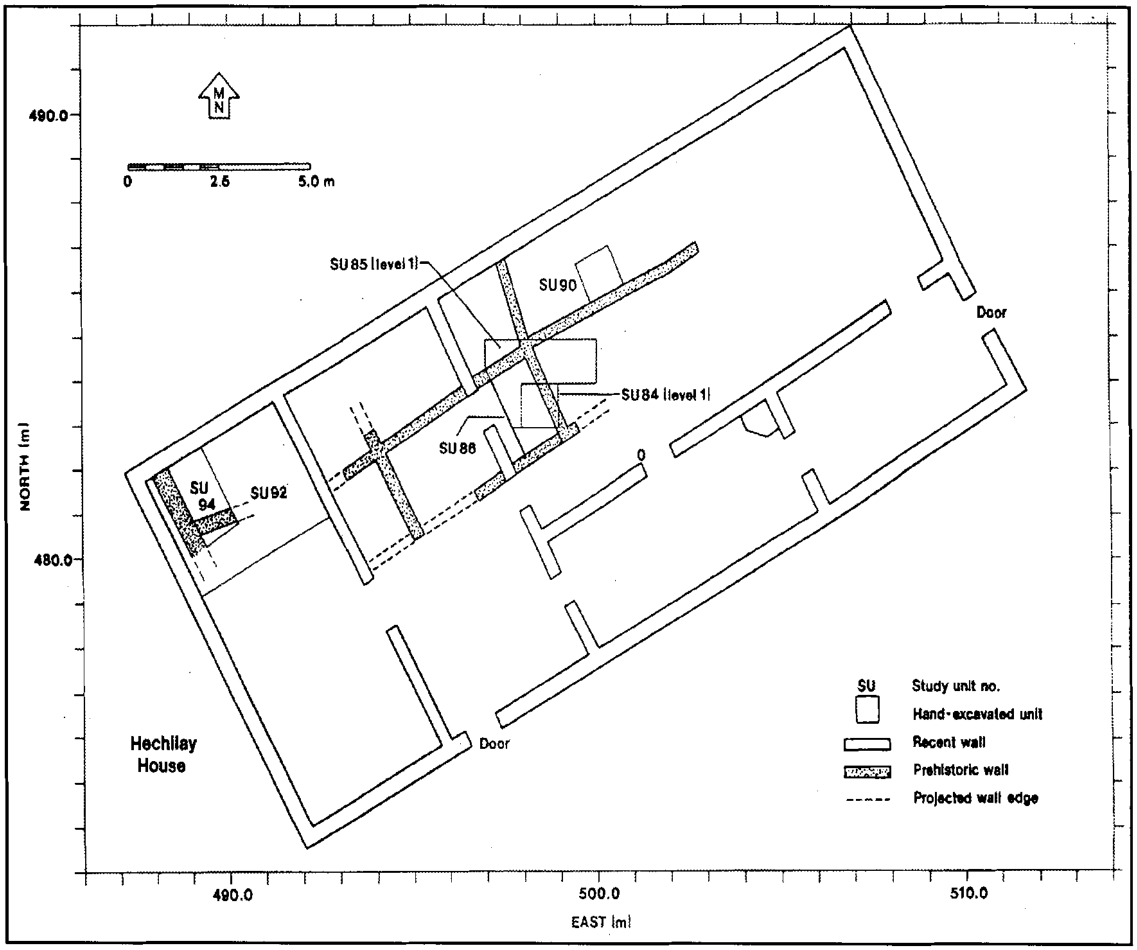

Figure 7. Plan view of the Hechilay Residence (from Howell 2001:45, figure 27)

Study Unit 86

Study unit 86 was a 1 x 2 m unit placed adjacent to and southwest of the area where the two early walls mentioned above intersect. Two rooms, one above the other, were identified in this unit (Features 75 and 76). The unit was excavated in 20 cm arbitrary levels. In the room above (Feature 75), the east, south, and north edges of the unit were flanked by masonry walls (Figure 8a).

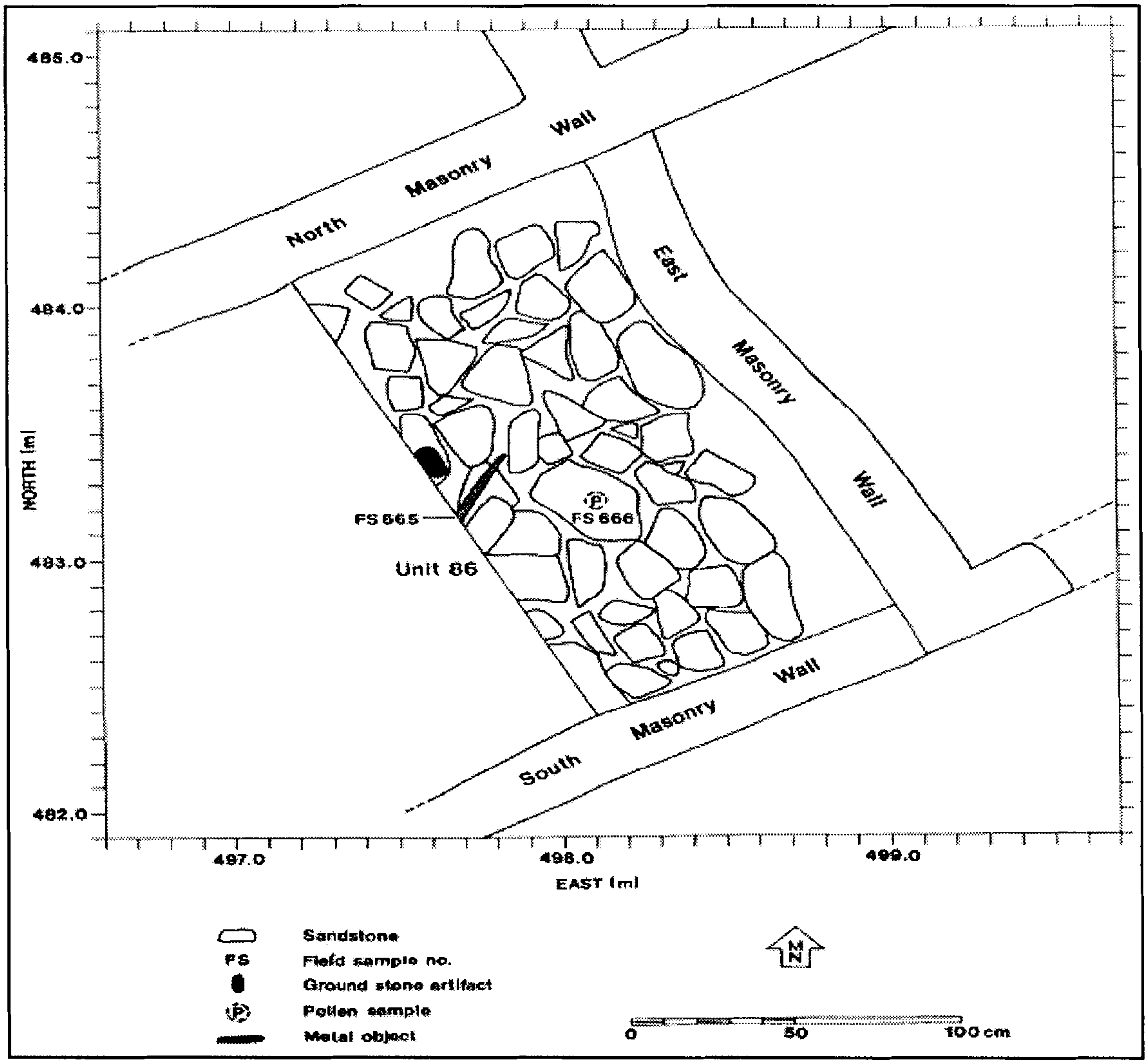

Figure 8a. Plan view of the floor in Feature 75 (from Howell 2001:48, figure 29)

Each wall was built of semi-coursed tabular sandstone masonry. Construction materials are different in the north wall, containing plaster and adobe bricks. A slab-lined floor along with a metal artifact were found in the northern portion of the unit. Midden deposits were uncovered beneath the stone floor. The stratigraphic profile of unit 86 (Figure 8b) indicates presence of materials such as sandstone, adobe bricks, charcoal, ash, and wall plaster. Most artifacts were recovered from the area above the floor, suggesting that the room was previously filled with trash. A recent wall foundation built from cinder block roofed earlier deposits. The room was filled with metal and other historic objects.

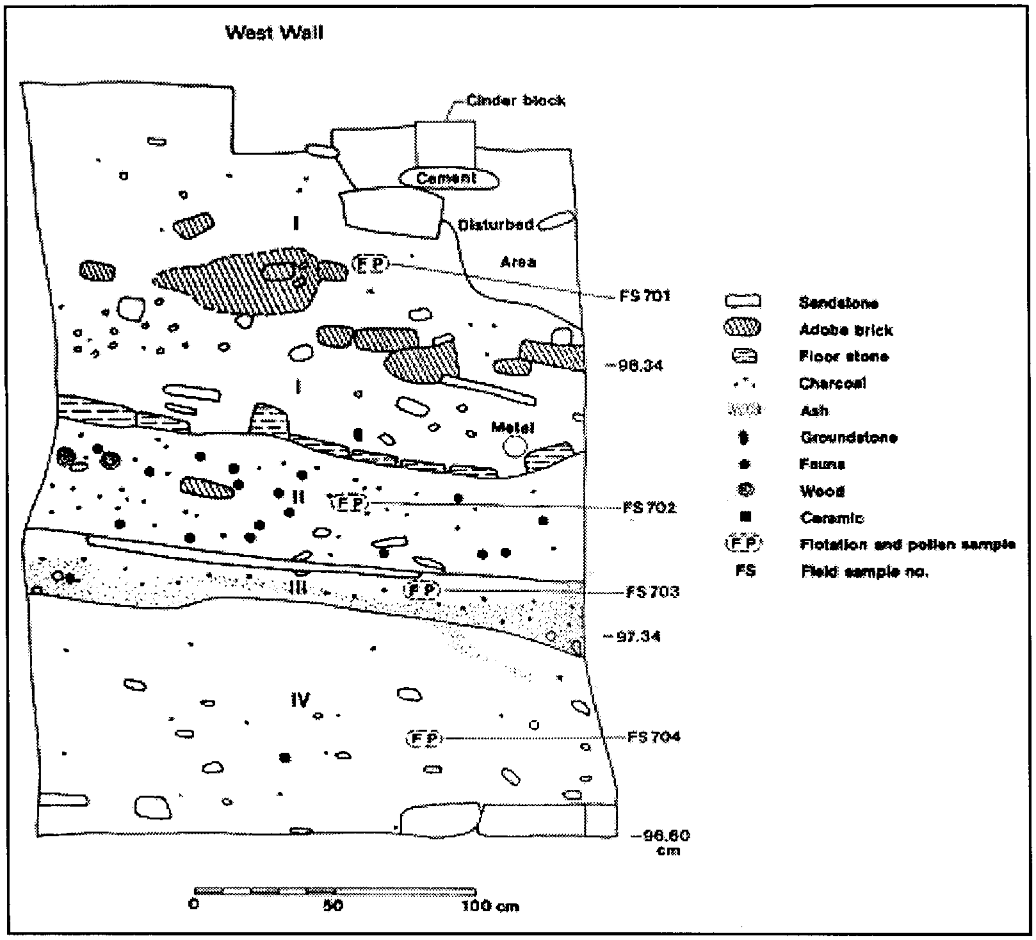

Figure 8b. Profile of the west sidewall of Unit 86 (from Howell 2001: 51, figure 31)

Seven layers were excavated in the room below (Feature 76). No floors, surfaces or floor features were uncovered. The walls are identical to those described in the room above. The south wall in Feature 76 was crossed by a beam, which was located 15 cm below the floor and might have been a roof. Three stratigraphic deposits were identified: one was a midden deposit containing high amounts of artifacts, ash, and charcoal; another had fewer artifacts, but was abundant in charcoal and ash; the last stratum had lowest artifact density along with extremely reduced amounts of charcoal and sandstone. Historic objects were found in most of the levels excavated in this unit.

Vacit Residence

Five excavation units were placed in the Gary Vacit residence, which is located immediately east of Small Plaza (Figure 9).

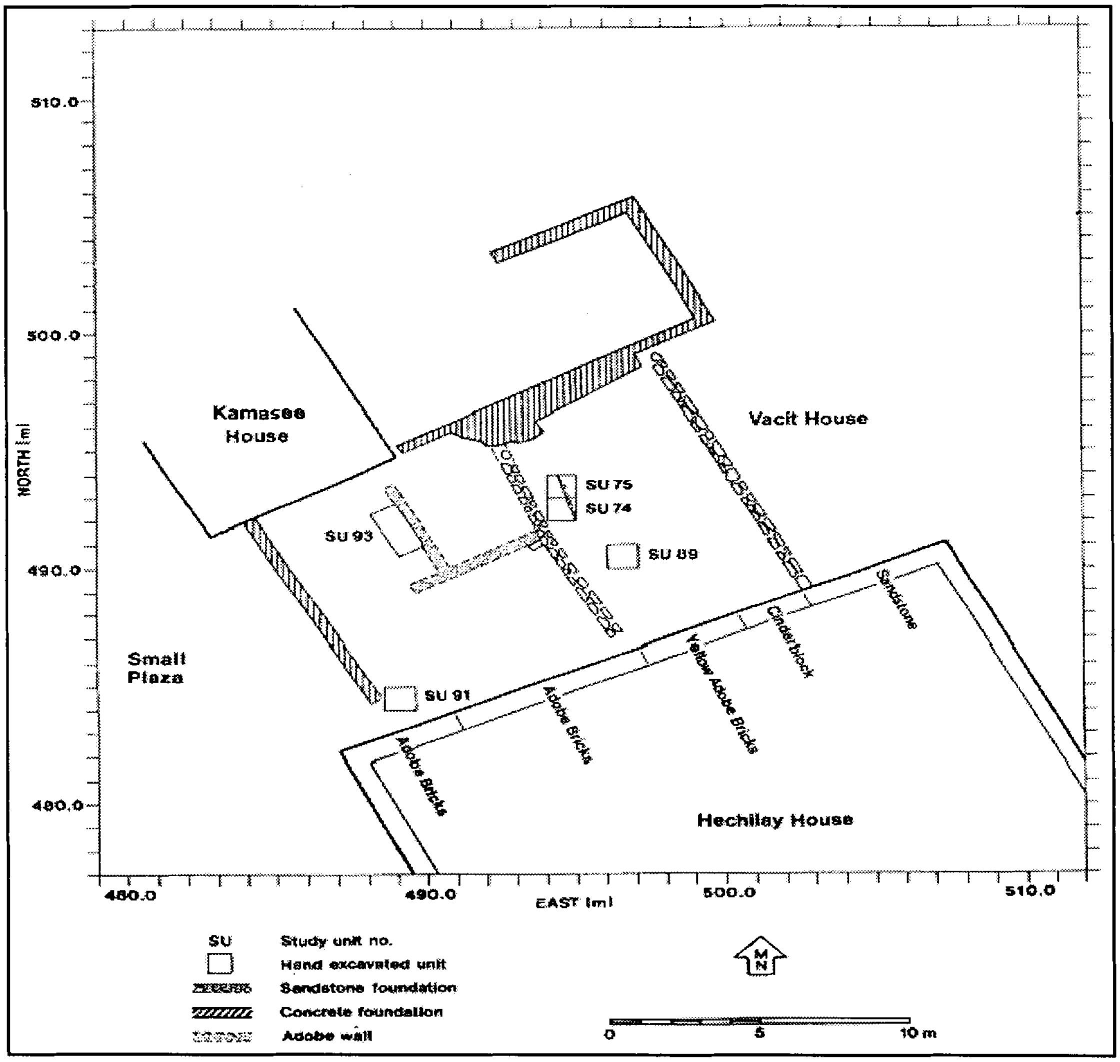

Figure 9. Plan view of Vacit area showing the location of Unit 93 (from Howell 2001:32, figure 20)

Features found in this residence include masonry walls, foundations consisting of uncoursed, large sandstone blocks similar to those in the Hechilay house, and a possible entryway. Pit, trash, and midden deposits also were uncovered. The presence of partially burned pieces of wood and vegetal material in some of the deposits suggests that they might be a result of intentional filling.

Study Unit 93

SU 93 was a 1 x 2 m excavation unit, placed in the northwestern portion of the Vacit house (see figure 8 above). The unit was excavated in 20 cm arbitrary levels. Two rooms, one above the other, were uncovered in this unit (Feature 81 and 82) (Figure 10).

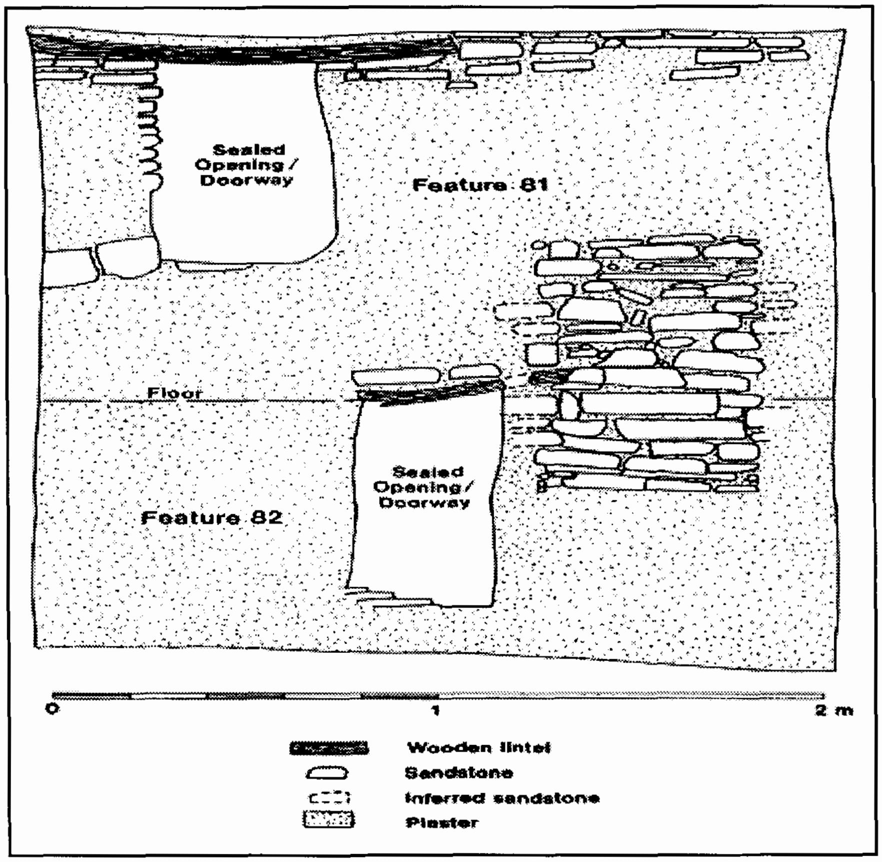

Figure 10. Profile of the east wall of unit 93 showing Features 81 and 82 (from Howell 2001:37, figure 23)

Feature 81 contained two floors. Blackware jars were found along the east and north walls. A sandstone wall was also exposed at the eastern side of Feature 81. Another wall running perpendicular to this wall was later uncovered. The wall to the east preserved remains of plaster, adobe, and some chinking. A rectangular surface opening was found near the ground surface. Feature 81 was composed of two strata. The lower stratum contained charcoal, small amounts of historic artifacts (metal and glass), adobe and plaster, and a few pieces of tabular sandstone. The upper stratum produced pieces of cloth, wood, leather, and metal. These deposits were attributed to intentional filling of the room after its abandonment.

Five 20 cm arbitrary levels were excavated in the room below (Feature 82). The east wall, previously uncovered in Feature 81, continued in Feature 82. Floors or floor features were not found. Another rectangular opening, below the floor in Feature 81, was found in Feature 82. Artifacts recovered from this feature might have resulted from intentional trash deposits. Table 16 shows a distribution of main animal taxa identified in the four study units.

Table 16. Frequency distributions (NISP) of main taxa within selected units

	SU 45	SU 46		SU 86			SU 93	
Taxon	M	PR	LH	M	PR	LH	PR	LH
Ovis aries	514	28	48	7	21	341	53	261
Capra hircus	40	15	17	2	2	62	19	73
Ovis aries/Capra hircus	99	19	21	3	13	69	9	69
Antilocapra americana	10	2	2	2	2	49	6	28
Odocoileus spp.	25	3	12	3	4	61	8	24
Perissodactyls	0	3	6	2	19	9	0	24
Sylvilagus spp.	84	10	33		28	28	3	61
Lepus spp.	26	4	14	1	20	35	5	32
Medium artiodactyls	421	111	192	10	29	387	38	297
Carnivores	16	138	87	3	1	11	5	13
Birds	5	11	17		1	11	1	11
Totals	1240	344	449	33	140	1063	147	893

Note: M = Mission; PR = Post-Revolt; LH = Late Historic

Diachronic Trends

Diachronic frequency distributions of bird and mammal taxa are presented in Tables 17 and 18. Although a large number of bird remains could not be assigned chronologically, a few trends are apparent.

Table 17. Frequency distributions of bird (Aves) taxa through time

Taxon	**Late Prehistoric**	Contact	**Mission**	**Post Revolt**	Late Historic	**Not Dated**
White pelican						1
American bittern				3		
Mallards and relatives	2	1	4		9	
Wood duck			1			
Vultures, Hawks, Eagles	1		1			
Hawks	4	20			7	9
Golden eagle						6
Falcons			1			
Sparrow hawk				15	1	
Grouse	1					
Turkey	45	8	1	1	7	5
~~Domestic chicken~~			1			
American coot				1		
Wader				1		
Owls	10				4	
Screech owl					1	
Great horned owl	18					
Common nighthawk					1	1
Woodpeckers		1		1		
Common flicker	1					
Perching birds		1		1	1	
Magpie					1	
Raven	4	9	1		5	
Large bird	2	3				15
Medium bird	7	6	1	1	8	3
Small bird				2		
Totals	95	49	11	26	45	40

Among birds, the dominant taxa are turkey and species of hawks and owls. Turkey frequencies are particularly low when compared to abundances recorded for other Pueblo IV sites (see Potter 1997) where turkey typically lies between jackrabbit and cottontail values. Specifically, in our data, turkey remains appear to decrease through time. A second pattern that we notice is that birds of prey such as owls and hawks have higher numbers in assemblages from prehistoric and contact deposits. Generally, a decline in taxonomic richness through time is not readily apparent in the bird distribution.

When examining the mammalian taxa distribution through time (Table 18) it is evident that the samples from Late Prehistoric and Contact periods are relatively small. The presence of a few European domesticates in pre-contact deposits might be the result of post-depositional processes (*e.g.*, bioturbation) that contributed to the movement of specimens from one layer to another. This is not unusual in stratigraphic deposits where earlier rooms are filled and new rooms built on the top. Similarly, some imprecision in stratigraphic analysis or dating might be responsible for mixed specimens. It is also possible that the Zuni had domestic animals prior to the official date of "contact" (*i.e.*, from the time of Spanish explorations in the Southwest), but more evidence is needed in order to elucidate this pattern.

Both cottontail and jackrabbit remains decrease through time. Rodent remains are scarcer in earlier times, while carnivore frequencies seem to increase in later times. Artiodactyls are less dominant in earlier deposits but the representation of both wild and domestic species increases through time.

Because this analysis concerns diet changes, relationships between taxa related to subsistence will be examined (*i.e.*, high-ranked *versus* low-ranked resources and indigenous *versus* European domesticates). A few general trends in food procurement are apparent in the diachronic analysis. Of most interest is the distribution of artiodactyls *versus* lagomorphs and turkey. As described in Chapter 1, the prey choice model predicts that with the addition of high-ranked resources (*e.g.*, domesticated livestock) to diet, one or more low-ranked prey items (*e.g.*, lagomorphs) will be dropped from the diet (Winterhalder 2001). One of the variables measured to assess contribution to diet was the relative abundance of high-ranked resources such as sheep *versus* low-ranked ones such as cottontails and jackrabbits.

Table 18. Frequency distributions (NISP) of mammalian taxa through time

Taxon	Late Prehistoric	Contact		Post Revolt	Late Historic	Not dated
Lagomorphs						
Rabbits and hares	1	2				
Cottontail	247	270	132	73	146	16
Jackrabbit or hare	115	89	137	45	104	6
Rodents						
Squirrels	1	1				
Ground squirrel			2	3	8	
Prairie dog	1	3	10	8	7	
Kangaroo rat			1		1	
Pocket gopher		1	2	2	1	
~~Mice: voles~~					~~1~~	
~~Wood rat~~	~~2~~		~~37~~	~~7~~	~~8~~	~~3~~
Wood rat or smaller	7	6	10	2	9	
Beaver	1		2			
Carnivores						
Carnivore				7		
Dog, wolf, coyote	7	6	17	85	71	15
Coyote				20	2	
Dog				14	3	1
Gray or red fox				2		
~~Bears~~					~~1~~	
Cats				3		
Lynx/Bobcat		1	3		1	1
Wolf size or larger carnivore					1	
Fox size or larger carnivore	4	4	15	24	39	8
Carnivore smaller than fox	1	1		6	8	
Perissodactyls						
Horse or donkey			1	14	1	
Horse	3		3	4	33	
Donkey				5	10	4
Artiodactyls						
Indeterminate Deer	9	10	46	24	124	41
Mule deer			10		1	
White-tailed deer					1	
~~Bighorn sheep~~					~~1~~	
Pronghorn	5	5	45	12	110	25
Sheep	57	5	629	202	1087	272

Table 18. Frequency distributions (NISP of mammalian taxa through time cont'd

Taxon	Late Prehistoric	Contact	Mission	Post Revolt	Late Historic	Not dated
Goat	4	1	58	49	235	55
Sheep or Goat	14	1	142	68	276	69
Cattle	3		1	6	43	13
Pig			1	1	1	3
Deer size artiodactyls	71	32	613	312	1509	354
Cattle size artiodactyls			4	7		3
Miscellaneous						
Jackrabbit size or smaller	1	4	10	5	9	
Deer size or smaller	1	2	112	71	167	26
Larger than deer			1	1	11	5
Large ungulate			6	18	65	14
Medium ungulate	12	19	69	50	304	121
Ungulate			1	1	6	
Total	567	463	2120	1151	4405	1055

Figure 11 shows a comparison between the relative frequencies of artiodactyls and lagomorphs through time. As predicted, the major trend is an increase in deer-size artiodactyls accompanied by a significant decrease in lagomorphs (chi-squared=2732.12; d.f.=4; P=0.00). During Contact, there may be a slight increase in lagomorph procurement at the expense of artiodactyls. During Mission, the pattern is reversed and we note an increase in deer-size artiodactyl procurement accompanied by a reduced importance of lagomorphs. This relative abundance of artiodactyls *versus* lagomorphs remains constant through Late Historic Period.

When deer-size artiodactyls are divided in the two subgroups (*i.e.*, domestic and wild) and compared to the lagomorph distribution through time, a similar pattern emerges because of the general dominance of domestic artiodactyls. Figure 12 shows a comparative diachronic distribution of artiodactyls *versus* lagomorphs. A rapid increase in domestic fauna occurs during Mission. Interestingly, we see a slight decrease in domestic artiodactyls during the Post-Revolt Period, but no decrease in wild artiodactyls. Overall, a slight increase in wild artiodactyl procurement through time is apparent.

Lagomorph procurement is most intense prior to the Mission Period and begins to decline during Mission and later historic periods.

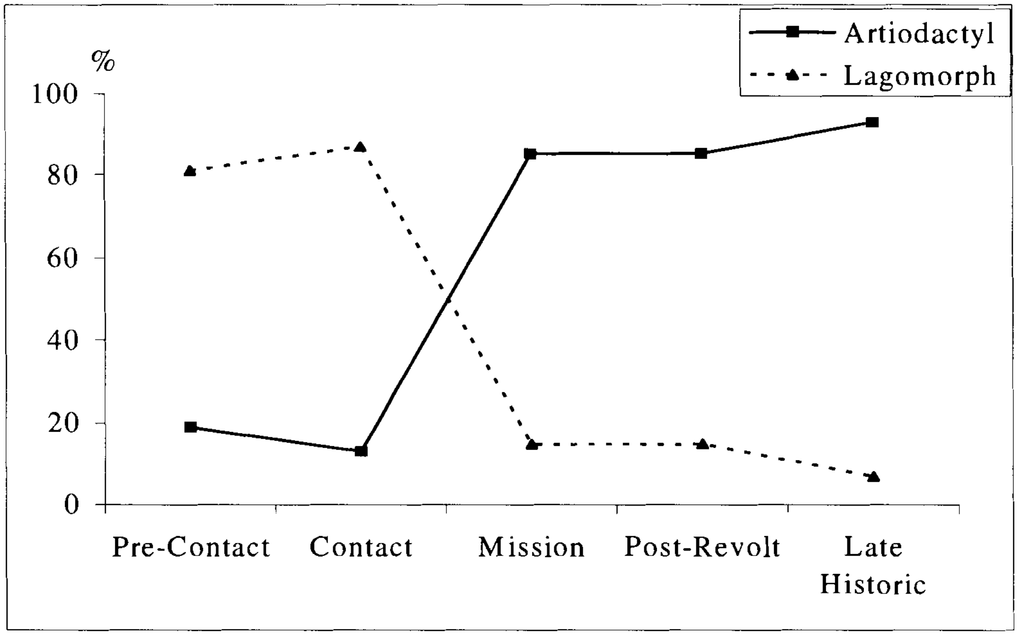

Figure 11. Relative frequencies (NISP) of lagomorphs *vs.* artiodactyls through time

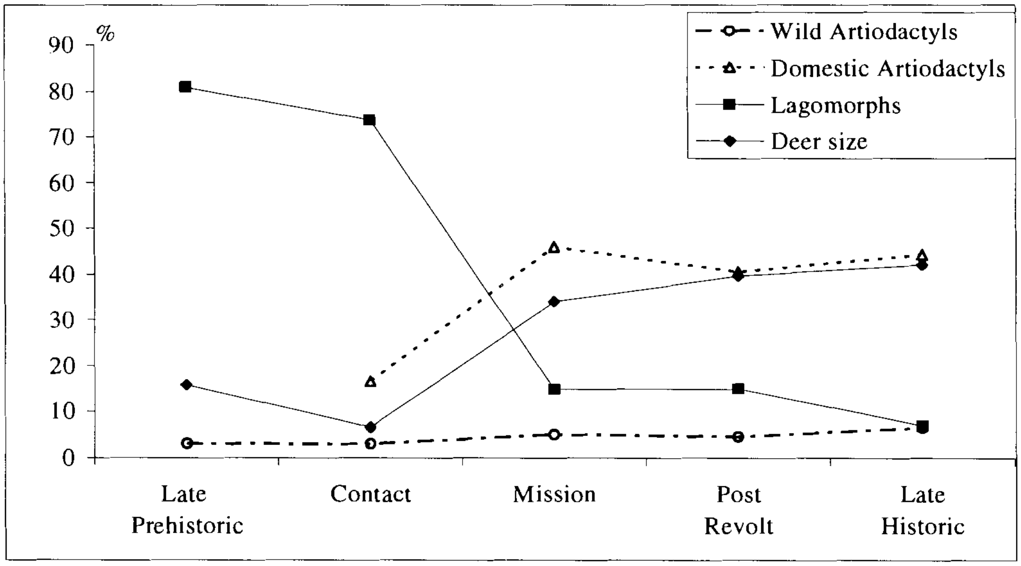

Figure 12. Relative frequency (NISP) distributions of selected mammal categories through time

A temporal examination of the distribution of the main species of artiodactyls and lagomorphs (Figure 13) shows that sheep occur in higher percentages during the Mission Period, a pattern that continues in Late Historic times. Both cottontail and jackrabbit are most abundant during Late Prehistoric and Contact Periods. Cottontails outnumber jackrabbits at all times, with the exception of Mission. Both species continue to be used as food but their importance appears to decline through time, especially after Contact. This drop may be the result of greater reliance on domestic artiodactyls such as sheep and goats. Alternatively, because data are expressed in percentages, it is possible that lagomorphs were hunted with equal intensity in all periods, with the addition of more and more domesticates through time. This is a standard problem in faunal analyses (Grayson 1984). One way to resolve it would be to compare numbers of bones with some other material (*e.g.*, potsherds), but the deposition rates of these too might change through time.

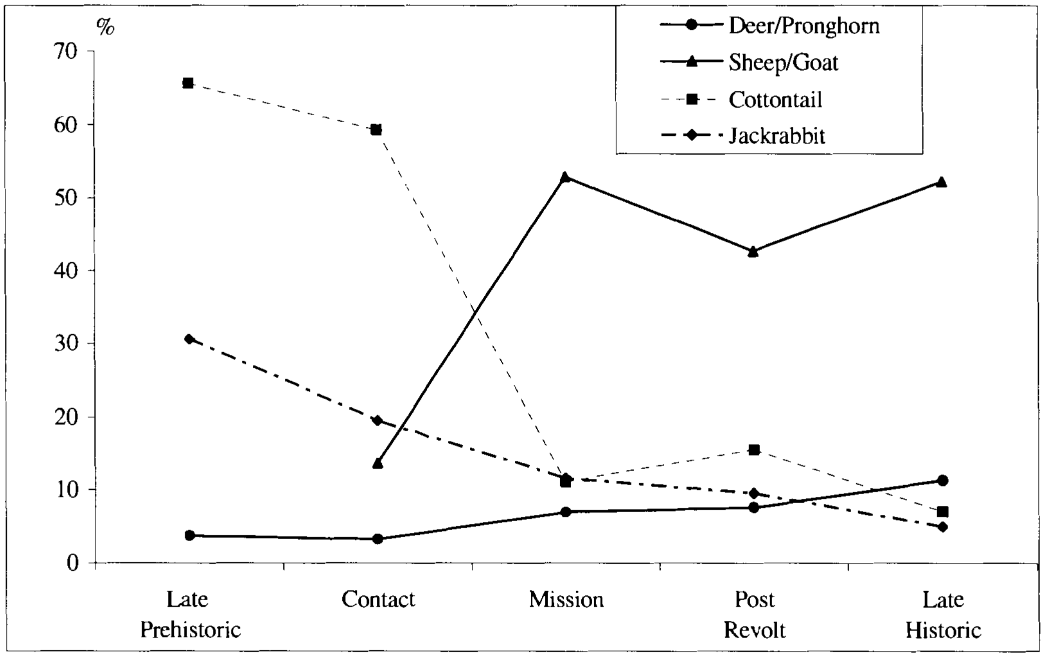

Figure 13. Diachronic frequency (NISP) distributions of selected taxa through time

In order to examine changes in the relative abundance of artiodactyls *versus* lagomorphs through time, the Artiodactyl Index (Szuter and Bayham 1989) was calculated. This index is useful when comparing taxa that differ substantially in size

(Broughton 1994a, 1994b). Artiodactyl Indices indicate similar trends for the three groups of artiodactyls (Table 19).

Table 19. Artiodactyl Indices (artiodactyls / artiodactyls plus lagomorphs) through time

Indices	Late Prehistoric	Contact	Mission	Post Revolt	Late Historic
Domestic Artiodactyl Index		0.19	0.75	0.73	0.86
Wild Artiodactyl Index	0.03	0.03	0.27	0.23	0.48
All Artiodactyl Index	0.18	0.26	0.85	0.85	0.93

The ratio of all deer-size artiodactyls (*i.e.*, wild + domestic + indeterminate) is higher than 0.50 in all historic periods. This suggests that artiodactyls as a whole contributed significantly more to Zuni diet than lagomorphs after Contact. A comparison of wild artiodactyls and lagomorphs also shows an increase in the procurement of wild artiodactyls after Contact and especially in Late Historic times, but lagomorphs are still important sources to the diet. Documentary sources (Cushing 1920; Stevenson 1904) note that game continued to be important in Zuni life in the late 19th century. Hunted artiodactyls are intimately connected with Zuni traditions since many bone elements are used as ceremonial paraphernalia. The increase in wild artiodactyl frequencies after the Pueblo Revolt is a particularly interesting pattern. It might be linked to a reinstatement of Zuni ceremonial life after the Spanish colonial era. The persistence of wild artiodactyl hunting even after the introduction of sheep is probably not an optimal strategy when considered from a purely economic point of view, and this suggests that other factors were involved. For example, hunting is often a defining male activity, and it may have been important for men to maintain this distinctive behavior, both as individuals and as members of sodalities. In this context, access to horses probably increased hunting efficiency. On the other hand, ethnographies frequently emphasize intense ritual activities taking place at Zuni Pueblo (*e.g.*, the Shalako annual ceremony) in the 19th century and the symbolic role and significance of wild animal products in Zuni ceremonial life and mythology (Cushing 1920; Stevenson 1904). Since the Small Plaza in the old core of the pueblo is intimately connected to ceremonial activities, remains of wild artiodactyls (as a manifestation of long-standing traditions) might be more abundant in this area. Support for this view comes from comparisons of data from this study to those from the Waterline Project (Olsen 1982) and Lower Pescado village (Etnier 1997), one of the large outlying farming villages in the 19th century. The Waterline Project, which sampled a wider area of Zuni Pueblo not related to ceremonial activities, indicates a higher ratio of domestic to wild artiodactyls than the Middle Village. Similarly, results from the Lower Pescado village suggest a decrease in lagomorphs and turkey through time, but no increase in wild artiodactyls, particularly during the Late Historic phase.

Domestic Artiodactyl Indices suggest a high increase in the frequency of domesticates *versus* lagomorphs from Mission times onward. The relative abundance of domestic artiodactyls is consistent throughout the historic period and supports the hypothesis that foraging efficiency increased after the introduction of the Old World species (see Table 19). The indices also suggest the presence of large numbers of domesticates at Zuni during Mission times but leaves open the question about how rapid incorporation of domestic stock into Zuni economy was. In view of present zooarchaeological data, whether sheep was incorporated rapidly into Zuni economy is uncertain. As discussed in Chapter 2, the Spanish missionaries controlled access to sheep in the 17th century and accounts do not indicate Zuni ownership of sheep prior to 1721 (Ferguson and Hart 1985; Hart 1995; Minge 1980; Webster 2003), which is about 30 years after the Pueblo Revolt. Economic changes within the mission system must have included a period of initial occupational training for the Zuni, who were not familiar with the techniques of husbandry and weaving introduced by the Spanish. Although sheep provided the Zuni with a valuable and productive alternative to previous subsistence strategies, Spanish control over flocks likely conditioned the adoption of sheep by the neophytes.

Zooarchaeological studies in the Southwest have often used the "lagomorph index" to examine the relative abundance of cottontails to jackrabbits. The index is simply the ratio between the number of cottontail remains and the number of cottontail plus jackrabbit remains. Jackrabbits thrive in areas cleared for fields, which suggests that the index is linked to the intensity of farming. This model presents a few problems. Firstly, although the two genera are sympatric, we would expect jackrabbits to be more frequent in areas with naturally open landscapes and this certainly seems to be the case when large-scale patterns are examined (*e.g.*, Driver 2002). Secondly, farming may actually improve habitats for cottontails by creating patchy environments with a variety of shrubs colonizing abandoned fields. Thirdly, there may be cultural factors that determine the relative frequency of the two genera. For example, Potter (1997) has argued that jackrabbits are more likely to be taken during communal hunts, while cottontails are more likely to be taken individually.

The lagomorph index varies through time (Table 20), reaching the highest values (*i.e.*, highest cottontail to jackrabbit ratios) in Late Prehistoric and Contact Periods. The index is also high during Post-Revolt times. High lagomorph indices are characteristic of Pueblo III (A.D. 1150-1275) cultures further north, and have been linked tentatively to intensification of agriculture and a reduction in long-range hunting trips (Driver 2002). Late prehistoric lagomorph indices were even higher at Scribe S Pueblo (0.84) and Pueblo de Los Muertos (0.84) (Potter 1997), and there may be an overall trend to lower values in the Zuni area. If this is a real trend, then the prey choice model would explain why the smaller prey (cottontail) was hunted less frequently once larger bodied domesticates became more available. However, continued hunting of small wild game may have been important for ritual reasons, even though domesticates provided a readily available source of meat (see Kent 1989).

Table 20. Lagomorph Indices (cottontails / cottontails + jackrabbit) through time

	Late Prehistoric	Contact	Mission	Post Revolt	Late Historic
Lagomorph Index	0.68	0.75	0.49	0.61	0.58

A chi-squared test was performed in order to evaluate if differences between lagomorph indices are significant and results are shown in Tables 21 a and b. The formula used to calculate the chi-squared is:

$$\chi^2 = \Sigma [(O-E)^2 / E]$$

The expected frequencies were derived from observed frequencies by pooling both cottontail and jackrabbit remains. The test shows that there is clearly significant variation in the abundance of lagomorphs at P=0.00. The correlation coefficient also supports the fact that the variation in lagomorph indices is not a result of sample size (r = 0.49; P = 0.39; $r^2 = 0.24$).

Table 21 a. Two-by-two way table showing the distribution of cottontails *vs.* jackrabbits

Chronology	Cottontails	Jackrabbits	Totals
Late Prehistoric	247 (231.68)*	115 (130.62)	362
Contact	270 (229.46)	89 (129.54)	359
Mission	132 (171.94)	137 (97.06)	269
Post-Revolt	73 (75.42)	45 (42.58)	118
Late Historic	146 (159.79)	104 (90.21)	250
Totals	868	490	1358

Note: * expected values are shown in parentheses

Table 21 b. Calculation table for obtaining the chi-squared value from data in Table 21 a

Chronology	O	E	O-E	$(O-E)^2$	χ^2
Late Prehistoric	247	231	15.62	243.98	1.05
Late Prehistoric	115	131	-15.62	243.98	1.86
Contact	270	229	40.54	1643.49	7.16
Contact	89	129	-40.54	1643.49	12.68
Mission	132	172	-39.94	1595.20	9.27
Mission	137	97	39.94	1595.20	16.43
Post Revolt	73	75	-2.42	5.85	0.07
Post-Revolt	45	42	2.42	5.85	0.13
Late Historic	146	160	-13.79	190.16	1.19
Late Historic	104	90	13.79	190.16	2.10
				Total	51.99

$-\chi^2 = 51.99$; d.f. = 4; P=0.00

An interesting trend is observed when galliformes (*i.e.*, turkey) are compared to lagomorphs (Table 22). As domestic artiodactyls were incorporated into Zuni economy, domestic turkey declined relative to wild lagomorphs. This pattern suggests that less attention was paid to raising smaller local domesticates when new, larger domesticates arrived.

Table 22. Frequency distribution of lagomorphs *versus* turkey through time

	Pre-Contact	Contact	Mission	Post -Revolt	Late Historic
Lagomorphs	363	361	269	118	250
Turkey	45	8	1	1	7
% Turkey	11.02	2.16	0.37	0.84	2.72

Contingency Analysis

Three contingency analyses are presented below to evaluate the chronological distribution in the faunal sub-assemblages from Middle Village. The analysis includes only remains that could be temporally assigned. Although ethnographies mention consumption of large rodents at Zuni, rodent remains are also excluded based on the assumption that most specimens are intrusive. The contingency tables are based on calculations of theoretically expected values and of standardized residuals as discussed in Chapter 3. In this statistical analysis, observed frequencies are compared to frequencies expected if all taxa are uniformly distributed throughout the temporal units. The observed values are equivalent to the relative frequencies of species recovered from each temporal context. Observed frequencies for selected taxonomic groups by temporal context are presented in Table 23 a. Expected frequencies were derived by pooling the remains from all temporal contexts (Table 23 b).

Table 23 c presents standardized residuals by taxonomic group and temporal context, along with absolute sums of standardized residuals. Values that lie more than one standard deviation below or above the mean indicate higher or lower than expected frequencies, respectively. Absolute standardized residual totals assist in evaluating the overall degree of variability of a given taxon and of animal groups within each temporal context. The Pearson Chi-square value indicates that the variability displayed is 'highly significant' at P < 0.001. The number of cells with small values (*i.e.*, NISP < 5) is not considerable (see Table 23 a) and therefore does not limit confidence in this test of significance.

As Shennan points out, the chi-squared test is not particularly informative about the strength of the relationship between the variables measured. The chi-squared test "simply measures the departures of expected from observed values; it simply tells us about the probability that a relationship exists" (Shennan 1997:113). As he further notes, a chi-squared result that is significant at the 0.001 probability does not necessarily indicate a stronger relationship than a result that is significant at the 0.05 level. The strength of a relationship between variables can be measured by deriving a standardized coefficient or the phi-squared. The phi-squared coefficient is obtained by dividing the chi-squared result by the number in the sample (Shennan 1997:115). Similar to correlation coefficients, the phi-square takes a value of 1.0 or -1.0 when the relationship between the variables is perfect and of 0.0 when no relationship is present.

Table 23a. Observed frequencies (NISP) of selected taxonomic groups through time

Taxon	Chronology					Totals
	Late Prehistoric	Contact	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	0	7	831	326	1642	2806
Wild artiodactyls	14	15	101	36	237	403
Medium Artiodactyls	71	32	613	312	1509	2537
Lagomorphs	363	361	269	118	250	1361
Perissodactyls	0	0	4	23	44	71
Canids	7	6	17	119	76	225
Other carnivores	5	6	18	42	50	121
Galliformes	45	8	1	1	7	62
Birds of prey	37	30	3	15	19	104
Other birds	4	3	6	7	11	31
Totals	546	468	1863	999	3845	7721

Table 23 b. Expected frequencies of major taxonomic groups through time

Taxon	Chronology					Totals
	Late Prehistoric	Contact	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	198.4	170.1	677.0	363.0	1397.0	2806
Wild Artiodactyls	28.5	24.4	97.2	52.1	200.7	403
Medium Artiodactyls	179.4	153.7	612.1	328.2	1263.0	2537
Lagomorphs	96.2	82.5	328.4	176.1	677.7	1361
Perissodactyls	5.0	4.3	17.1	9.2	35.3	71
Canids	15.9	13.6	54.3	29.1	112.0	225
Other carnivores	8.5	7.3	29.2	15.7	60.2	121
Galliformes	4.4	3.7	14.9	8.0	30.8	62
Birds of prey	7.3	6.3	25.0	13.4	51.8	104
Other birds	2.2	1.8	7.5	4.0	15.4	31
Totals	546	468	1863	999	3845	7721

Table 23c. Standardized residuals* of selected taxonomic groups through time

Taxon	Chronology					Total
	Late Prehistoric	Contact	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	**-14.08**	**-12.50**	5.91	-1.94	6.54	40.97
Wild artiodactyls	-2.71	-1.90	0.38	-2.23	2.56	9.78
Medium Artiodactyls	-8.09	**-9.82**	0.03	-0.89	6.90	25.73
Lagomorphs	**27.29**	**30.66**	-3.27	-4.37	**-16.43**	82.02
Perissodactyls	-2.24	-2.07	-3.17	4.55	1.45	13.48
Canids	-2.23	-2.06	-5.06	**16.66**	-3.40	29.41
Other carnivores	-1.21	-0.49	-2.07	6.65	-1.32	11.74
Galliformes	**19.39**	2.18	-3.60	-2.47	-4.29	31.93
Birds of prey	**10.93**	**9.43**	-4.11	0.42	-4.55	29.44
Other birds	1.22	0.81	-0.54	1.49	-1.12	5.18
Total	89.39	71.92	28.14	41.67	48.56	279.68

Pearson Chi-square = 3741.07; d.f. = 36; P = 0.000; phi-square = 0.68

* Calculated as: (Observed-Expected)/$\sqrt{\text{Expected}}$. Values which fall beyond (higher or lower than) one standard deviation of the mean standardized residual value (*i.e.* - 8.11 + 9.31) are in bold. Totals represent sums of absolute values

Lagomorphs, domestic artiodactyls, and birds of prey display the greatest overall variability among the taxa. Specifically, Lagomorph remains are more abundant than expected in the samples from Late Prehistoric and Contact times. By contrast, they are less abundant than expected in Late Historic context. Domestic artiodactyls values are substantially lower than expected in Late Prehistoric and Contact times. The remains of birds of prey and Galliformes are over-abundant in earlier periods.

The Late Prehistoric and Contact samples display the highest degree of deviation from expected values among all temporal contexts (note the high absolute residual values of 89.39 and 71.92, respectively). Over-abundant taxa in Late Prehistoric samples include Lagomorphs, Galliformes, and "birds of prey". In the assemblage dated to Contact times, lagomorphs and 'birds of prey' are more common that expected, while frequencies of domestic and medium-size artiodactyls are lower. Canids are over-abundant in Post-Revolt times while Lagomorphs are scarcer than expected in the Late Historic. In this analysis, data from Mission do not indicate any variability in species distribution, while the Post-Revolt and Late Historic samples demonstrate minor variation. Absolute standardized residual totals are comprised between 28.14 and 48.56. These three assemblages have provided larger samples of bones. Therefore, the pattern observed suggests that differences in sample size between earlier and later assemblages might strongly affect the analysis. In order to assess the sample size contribution to results, samples dated to Late Prehistoric and Contact times were grouped and a second contingency analysis was undertaken (Tables 24 a, b, c). Similarly, "Canids" and "Other Carnivores" were grouped under "Carnivores" and "Galliformes" were added to "Other birds" category.

Table 24a. Observed frequencies (NISP) of selected taxonomic groups through time

Taxon	Chronology				Totals
	Prehistoric/ Contact	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	7	831	326	1642	2806
Wild artiodactyls	29	101	36	237	403
Medium Artiodactyls	103	613	312	1509	2537
Lagomorphs	724	269	118	250	1361
Perissodactyls	0	4	23	44	71
Carnivores	24	35	161	126	346
Birds of prey	67	3	15	19	104
Galliformes + other birds	60	7	8	18	93
Totals	1014	1863	999	3845	7721

Table 24b. Expected frequencies of selected taxonomic groups through time

Taxon	Chronology				Total
	Prehistoric/ Contact	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	368.5	677.0	363.0	1397.0	2806
Wild artiodactyls	52.9	97.2	52.1	200.7	403
Medium Artiodactyls	333.2	612.1	328.2	1263.0	2537
Lagomorphs	178.7	328.4	176.1	677.7	1361
Perissodactyls	9.3	17.1	9.2	35.3	71
Carnivores	45.4	83.5	44.2	172.3	346
Birds of prey	13.6	25.1	13.4	51.8	104
Galliformes + other birds	12.2	22.4	12.0	46.3	93
Totals observed	1014	1863	999	3845	7721

Table 24c. Standardized residuals* of selected taxonomic groups through time

Taxon	**Chronology**				**Total**
	Prehistoric/ Contact	**Mission**	**Post Revolt**	**Late Historic**	
Domestic Artiodactyls	**-18.83**	5.91	-1.94	**6.54**	33.22
Wild artiodactyls	-3.28	0.38	-2.23	**2.56**	8.45
Medium Artiodactyls	**-12.61**	0.03	-0.89	**6.9**	20.43
Lagomorphs	**40.78**	-3.27	-4.37	**-16.43**	64.85
Perissodactyls	-3.05	-3.17	4.55	**1.45**	12.22
Carnivores	-3.18	-5.3	**17.37**	**-3.52**	29.37
Birds of prey	**14.43**	-4.41	0.42	**-4.55**	23.81
Galliformes + other birds	**13.67**	-3.25	-1.16	-4.16	22.24
Total	109.83	25.72	32.93	46.11	214.59
Pearson chi-square = 3489.33; d.f. = 21; P=0.000; phi-square = 0.67					

* Calculated as: (Observed-Expected)/√Expected. Values which fall beyond (higher or lower than) one standard deviation of the mean standardized residual value (*i.e.* – 10.11 + 11.07) are in bold. Totals represent sums of absolute values

Overall, there is no considerable difference between the results of the two contingency analyses. The sample dated to earlier times continues to display greatest variability (absolute total residual value of 109.83). A marked variation in the chronological distribution of taxa is generally apparent. This is primarily the product of the differences in taxon frequencies within and between assemblages. Specifically, Lagomorphs are more abundant than expected in earlier times.

The same is true for Galliformes and 'birds of prey'. Not surprisingly, artiodactyl values are lower than expected in earlier deposits and increase in later ones. The assemblage from Mission still shows a relatively uniform distribution and lowest taxonomic variability, with an absolute residual value of 25.72. Similarly, the samples from later times are relatively homogenous, with Carnivores being over-abundant in Post-Revolt and Lagomorphs extremely scarce in Late Historic times. This second analysis reveals that sample size has no major impact on the results.

In order to distinguish more subtle differences in taxon frequencies among samples from later periods (*i.e.,* Mission, Post-Revolt, and Late Historic), a third contingency analysis was undertaken (Tables 25 a, b, c). Table 25 indicates taxonomic variability in the Mission and Post-Revolt samples that was previously obscured by the way in which the data were grouped. Lagomorphs and Carnivores are scarcer than expected in the Mission Period, a pattern that was not evident before. Artiodactyls, on the other hand, have lower than expected values in Post-Revolt samples.

Table 25a. O~~bserved frequencies (NISP) of selected taxonomic groups throug~~h time

Taxon	**Chronology**			**Totals**
	Mission	**Post Revolt**	**Late Historic**	
Domestic Artiodactyls	831	326	1642	2799
Wild artiodactyls	101	36	237	374
Medium Artiodactyls	613	312	1509	2434
Lagomorphs	269	118	250	637
Perissodactyls	4	23	44	71
Carnivores	35	161	126	322
Birds of prey	3	15	19	37
Other birds	7	8	18	33
Totals	1863	999	3845	6707

Table 25b. Expected frequencies of selected taxonomic groups through time

Taxon	Chronology			Totals
	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	777.5	416.9	1605.0	2799
Wild artiodactyls	103.9	55.7	214.4	374
Medium Artiodactyls	676.0	362.5	1395.0	2434
Lagomorphs	176.9	94.9	365.2	637
Perissodactyls	19.7	10.6	40.7	71
Carnivores	89.4	47.9	184.6	322
Birds of prey	10.3	5.5	21.2	37
Other birds	9.1	4.9	18.9	33
Totals	1863	999	3845	6707

Table 25c. Standardized residuals* of selected taxonomic groups through time

Taxon	Chronology			Totals
	Mission	Post Revolt	Late Historic	
Domestic Artiodactyls	1.92	**-4.45**	0.93	7.3
Wild artiodactyls	-0.28	-2.64	1.54	4.46
Medium Artiodactyls	-2.42	-2.65	3.04	8.11
Lagomorphs	**-6.92**	2.37	**-6.02**	15.31
Perissodactyls	-3.54	3.82	0.51	7.87
Carnivores	**-5.75**	**16.32**	-4.31	26.38
Birds of prey	-2.27	4.04	-0.48	6.79
Other birds	-0.71	1.39	-0.21	2.31
Totals	23.81	37.68	17.04	78.53

Pearson chi-square = 515.62; d.f. = 14; P = 0.000; phi-square = 0.27

Values which fall beyond (higher or lower than) one standard deviation of the mean standardized residual value (*i.e.* –4.43 + 5.01) are in bold.

Overall, several distinctive patterns about the nature of the diachronic variability in the assemblage are apparent. Generally, we can note a marked variation in taxon frequencies between chronological units. In particular, earlier contexts display higher variability in taxon frequencies as indicated by the absolute total values of the standardized residuals. A uniform distribution of taxa and lower absolute total standardized residual values characterize later assemblages. This pronounced variability does not seem to be related to differences in sample size. Earlier deposits display an abundance of Galliformes, birds of prey, and Lagomorphs, associated with a paucity of Artiodactyls. This pattern is consistent with an economy mainly based on hunting small prey and raising turkey. Artiodactyls have an increased representation beginning with Mission, which is associated with the introduction of Old World domesticates. Lagomorphs decrease through time and the same stands true for birds. Carnivores, on the other hand are over-represented during the Post-Revolt Period.

Both contingency analysis and relative frequency distributions presented earlier in the chapter indicate temporal trends that support the predictions of the prey choice model. That is, with the introduction of high-ranked, readily available resources such as sheep, low-ranked taxa become less predominant in the overall diet strategies.

Chapter Summary

A relatively large collection of animal bones was recently recovered from excavations in the Middle Village area of Zuni Pueblo, out of which 90% were chronologically assigned. The presence of a few European domesticates in supposedly pre-contact deposits indicates either some post-depositional movement of specimens or imprecision in stratigraphic analysis or dating.

Prior to the Spanish influence, Zuni subsistence economy was dominated by cottontails and jackrabbits, a pattern similar to other sites in the region. We do not have enough evidence to fully understand the processes whereby the Zuni people adopted domestic artiodactyls. However, the change in the economy appears to be relatively rapid, and sheep and goat became important staples early, and remained so until recent times. Cattle and pig are rare overall and may represent animals obtained from outside Zuni. Horse and donkey are also scarce, but this is typical for equids kept primarily for transportation.

Sheep in particular seem to have become the most important Zuni domestic animal. Once domestic animals were adopted, the frequency of cottontails and jackrabbits declined, as did turkey, an indigenous domesticate. We suggest this pattern is readily explained by the prey choice model, which predicts that smaller-bodied species will be replaced by newly available, larger-bodied species if energy costs of capture are similar.

The exploitation of wild artiodactyls (mainly deer and pronghorn) did not decline. Relative to lagomorphs, wild artiodactyls increased in frequency, and the ratio of domestic to wild artiodactyls is fairly constant in the assemblages at about 8:1.

As previously suggested, the persistence of wild artiodactyl hunting cannot be adequately explained from a purely economic point of view, which suggests that other factors were probably involved. Beside the role of hunting as a defining activity of male identity, wild animal products played important symbolic roles in ceremonies, for example through consumption of meat or through use of hides, scapulae, or antlers in ceremonial clothing. Support for this view comes from a comparison of data from this study with an earlier study of assemblages from Zuni Waterline trenches and one of the outlying farming villages that functioned in the 19th century. The Waterline project sampled the village quite widely, whereas the current project focused on some areas known to be important in religious ceremonies. The wider sample produced ratios of domestic to wild artiodactyls of about 18:1, suggesting that wild animals may be more common in areas associated with ceremonies. Many of the bird species found in the Middle Village area were likely procured for similar ceremonial purposes. Additionally, the study of the fauna from the outlying village does not indicate an increase in wild artiodactyl procurement in Late Historic times.

CHAPTER 5

SHEEP AND GOAT AGE PROFILES

Introduction

This chapter examines sheep and goat age at death. This type of analysis is relevant to studies of flock management practices, such as the utilization of animals for meat and/or their selection for byproducts. The chapter is structured in two sections. The first part reviews published mortality profile models for sheep and goats. The second section describes the methods used to determine age profiles, the sample, results, and interpretation. Changes in strategies through time are explored by looking at age class distributions in diachronic sub-assemblages.

Models of Herd Management Strategies

Payne's Mortality Profiles

In studies of herd management strategies, archaeological data are often compared with postulated age distributions based on the assumption of optimization for different products. Payne (1973) developed one of the most influential and widely used models for flock management. Sheep and goats are kept for meat, milk, and wool and maximization of one or more of these products is generally expected. This suggests that the relative economic importance of these different products will dictate the decisions of the herder. Payne postulated three hypothetical models for flocks of sheep and goats, based on the assumption that the economic goals of the herder will affect the age and sex of the animals culled. He argues that the age at which herders slaughter animals depends on the nutritional value placed on their products, the characteristics of the stock, and the seasonal variation in the quality and availability of food. He also argues that herders' decisions may be influenced by factors such as production costs, seasonal demands, variations in selling price throughout the year, and availability of storage (Payne 1973:31). His models were tested against archaeologically-derived age distributions based on eruption and attrition data. The kill-off patterns that might result from different economic emphases are shown in Figure 14. Note that a cumulative computation of the age classes between four and ten years is presented. The percentages in each individual age class older than four years of age would be lower.

Meat Production

The first model predicts the mortality profile when the goal of herding is meat production. According to the model, in a domestic flock raised as a source of meat most males are slaughtered when they reach their maximum weight or slightly earlier, when their growth curve begins to decline. Optimum weight gain in sheep is considered to be around 2-3 years or 18-30 months; the rationale behind this decision is purely economic. After this age, males contribute nothing further to the flock and only compete for fodder with females. As a result, only the males needed as reproductive stock continue to be retained. Young females are slaughtered if injured or barren. The model estimates that around 30% of the total death assemblage will be composed of animals that die or are culled during their first year of life. This category includes neonatals (in the 0-2 months range) and infant mortality among both females and males. Twenty percent of the animals are killed in their second year and 20% in their third. These age categories target males that have attained optimum weight gain and are not useful as reproductive stock. In some instances, herder's concerns are flock security; in this case, surplus of young animals will be maintained in order to insure replacement of losses resulting from injuries and disease. Young females will be kept in large numbers if the intention is to increase the flock. The intensity of culling diminishes after three years. Thus less than 10% of the death assemblage will be animals in their fourth year and around 25%, mainly females, survive to old age. Adult ewes and does will be slaughtered if injured, barren, or beyond reproductive age (around 6-7 years in sheep). In summary, in a meat emphasis, the mortality pattern would focus on young males, with a secondary peak on adult females.

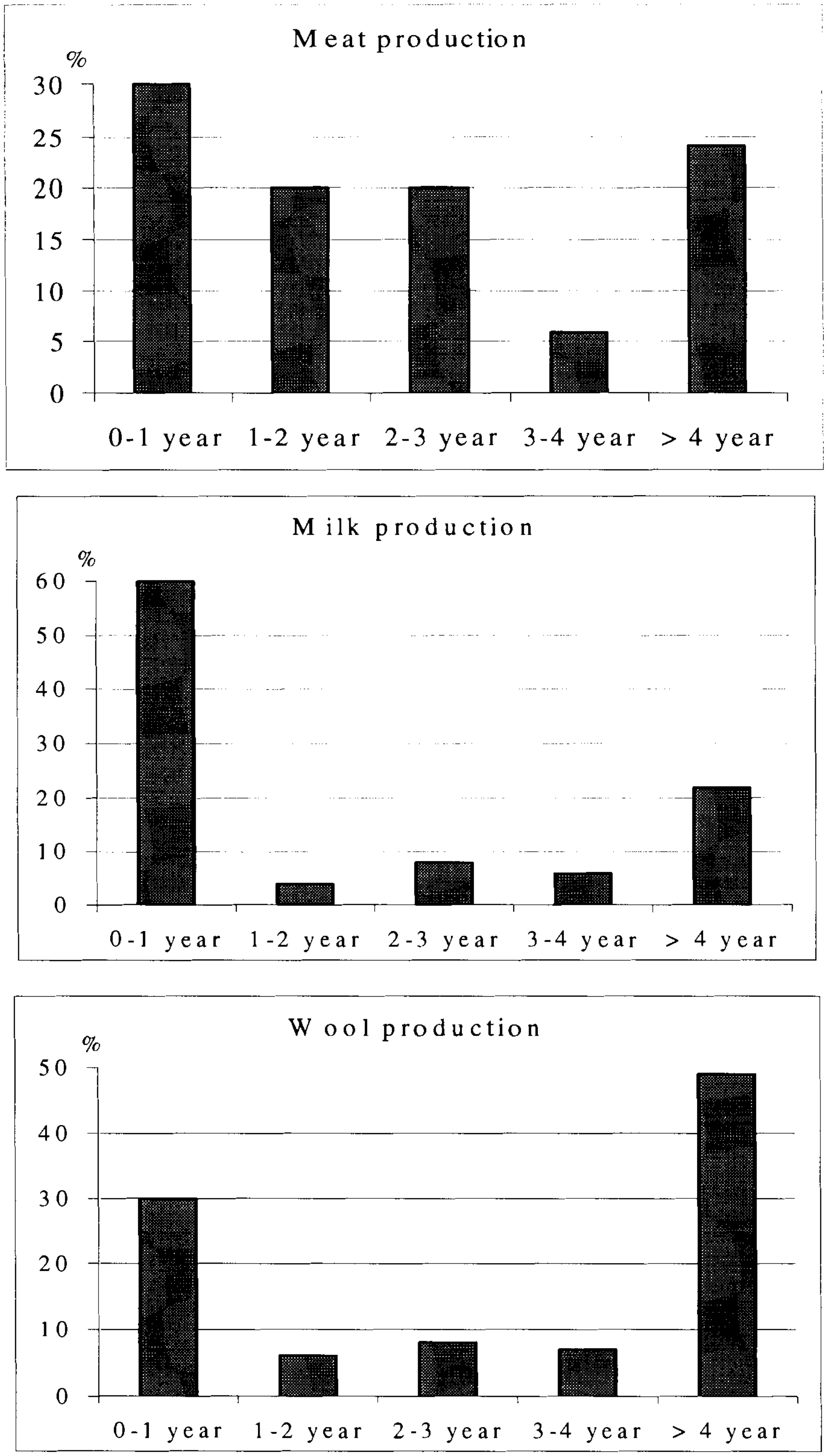

Figure 14. Expected kill-off patterns, expressed in percentages of the total death assemblage (after Payne 1973:282, 283, 284)

Milk Production

The second model predicts the kill-off pattern when herders focus on obtaining milk and dairy products from the flocks. In this case, a large segment (around 60%) of the total death assemblage is slaughtered or dies during the first year. This percentage includes infant mortality and the surplus of male lambs and kids (around 6-9 months) not kept as reproductive stock. The overall purpose of this culling strategy is to control lambs from competing for pasturage with milk-producing females and from consuming milk. The intensity of culling decreases substantially after the first year. Around 20% in the death assemblage comes from animals slaughtered between one and four years and another 20% from animals between four and ten years. As with the previous model, animals slaughtered after one year of age result from the breeding selection among reproductives. Young males and females are similarly culled if barren or injured. A larger number of adult females is kept to old age than males and will be slaughtered as they become injured or their reproductive capabilities diminish.

Wool Production

A different kill-off pattern is expected in a wool economic emphasis. The distribution shows an increased rate of survival of both sexes to adult age. A large segment of the death assemblage (up to 50%), both males and females, comes from adult animals. Herders will keep the lambs (mostly females) needed for flock replacement and castrate the surplus of males not used for breeding. This way, males can be raised to older ages as wool-producing wethers. Only 30% of the death assemblage is composed of animals in the first year. Animals are slaughtered for meat as they get older and the quality of wool deteriorates (at about 6 years in sheep).

As Payne (1973: 32) points out, herders generally keep flocks for more than one product and a combination of these patterns may be expected. On the other hand, the relative importance of different products is dependent upon the type of economy practiced. For example, in a subsistence economy, strategies will be based on the immediate needs of the group or family, whereas in a cash economy, on market forces. Religious practices, such as taboos against killing or consuming certain animals and sacrifices of animals at different times of year or on ceremonial occasions are equally important factors that can affect the selection of animals.

The expected kill-off patterns discussed above represent percentages of animals killed in each age class or the death assemblages. Table 26 and Figure 15 illustrate the difference between death, survivorship, and mortality profiles, assuming that 200 lambs are born every year and that sheep survive up to ten years.

Table 26. Example of differences between death, survival, and mortality profiles

Age class	Nr. alive	Nr. that die	% death assemblage	% survival	% mortality
0-2 months	200	20	10	90	10
2-12 months	180	40	20	70	22
1-2 years	140	40	20	50	29
2-3 years	100	30	15	35	30
3-4 years	70	5	2.5	32.5	7
4-5 years	65	5	2.5	30	8
5-6 years	60	10	5	25	16
6-7 years	50	15	7.5	17.5	30
7-8 years	25	15	7.5	10	40
8-9 years	20	10	5	5	50
9-10 years	10	10	5	0	100

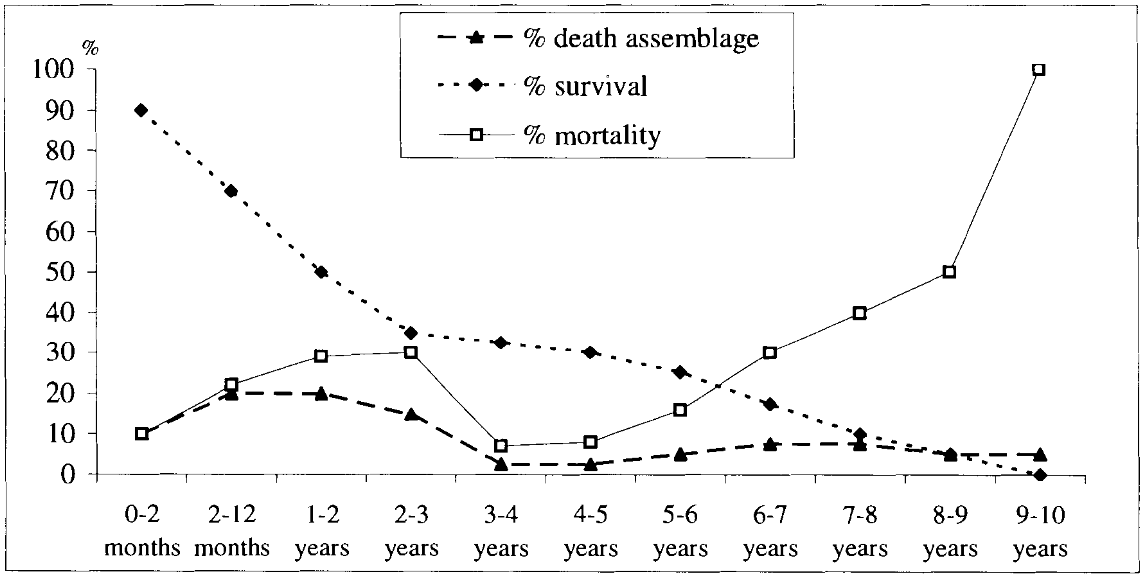

Figure 15. Graphic representation of the differences between death, survival, and mortality profiles

The survivorship distribution shows percentages of animals of the original birth cohort surviving at each age class. The mortality distribution, on the other hand, shows the percentage of animals killed in each age class up to the point where the last survivors die. The death assemblage curve illustrates what we should theoretically expect in the archaeological record (*i.e.,* of kill-off patterns). However, archaeological materials are impacted by taphonomic processes and, as a result, the percentages in each age class can be lower than expected.

Critiques to Payne's mortality profiles are summarized in Cribb (1984, 1985, 1987) and Munson (2000) and will be reviewed below.

Payne's Mortality Profiles Revisited

Taphonomic factors related to preservation, the impact of scavengers, and even cooking procedures could affect archaeological assemblages. Consequently, archaeologically-derived mortality profiles may not fit theoretical models very well. Payne's mortality models include neonatals (0-2 months) in the young category (< 12 months). Munson (2000) and Cribb (1985) reasonably argue that the remains of neonatals are extremely fragile and hardly survive in archaeological assemblages. Therefore, lower percentages of animals younger than one year should be expected when dealing with archaeological material. Munson notes that numerous mortality profiles derived from modern, ethnographic, and historic data do not include neonatal deaths. For these reasons, he excludes neonatals and presents recalculations of Payne's mortality profiles. Assuming that neonatals account for one-half of the natural deaths in the 0-12 month age class, the percentages for the 2-12 month, 1-2 year, 2-3 year, 3-4 year, and ≥4-year categories should be as follows: meat emphasis: 18, 24, 24, 6, 29%; milk emphasis: 53, 4, 4, 4, 35%; wool emphasis: 18, 6, 9, 8, 59% (Munson 2000:391). Expected distributions excluding neonatals are shown in Figure 16.

Actualistic studies (*e.g.*, Binford & Bertram 1977; Payne & Munson 1985; Munson 2000; Selvaggio and Wilder 2001) have demonstrated that mandibles and bones of different ontogenetic ages have dissimilar survival rates when ravaged by scavengers in that adult mandibles preserve better than those of individuals younger than 12 months.

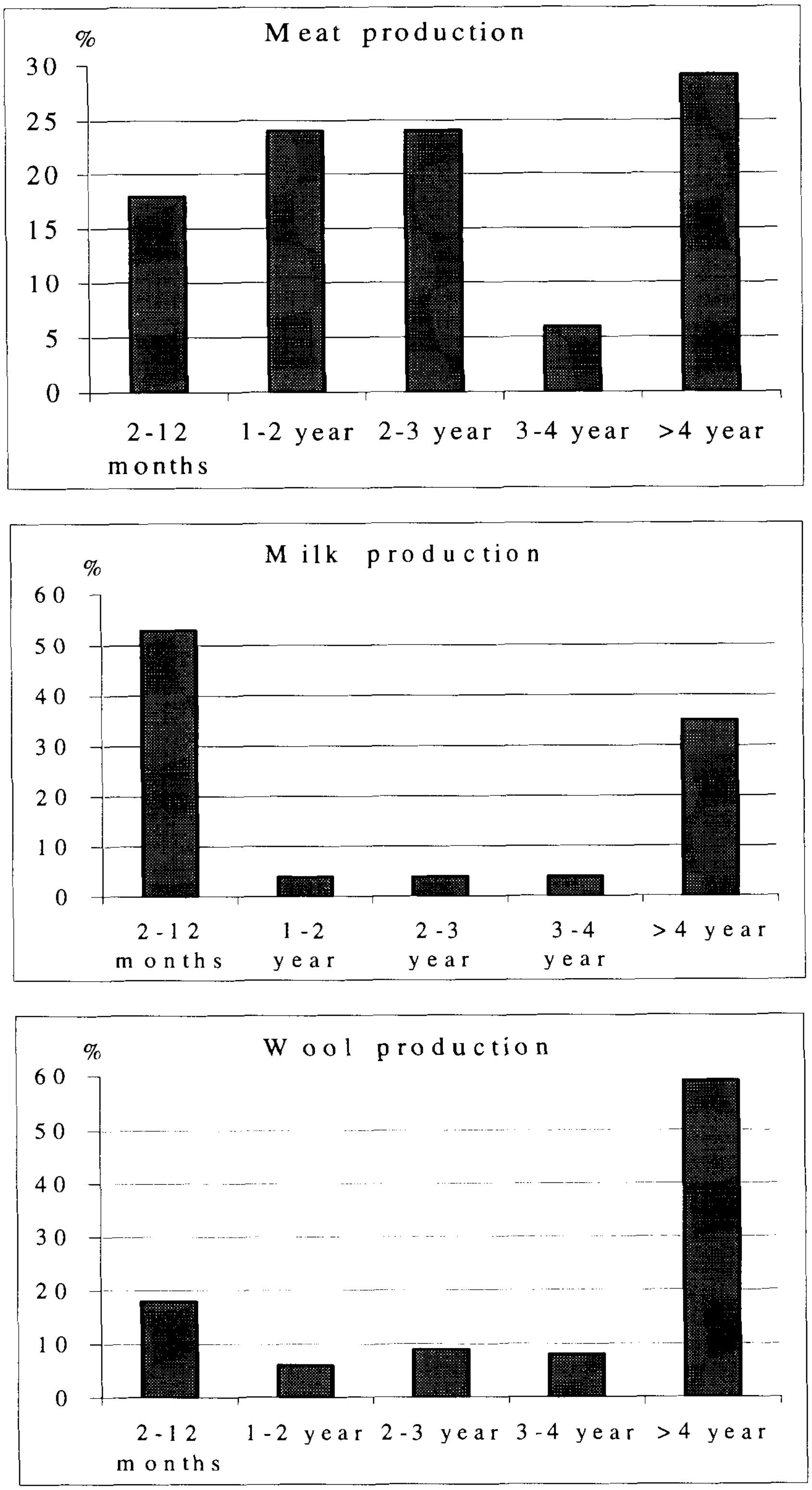

Figure 16. Expected kill-off patterns excluding neonatals (after Munson 2000:391)

Additionally, a recent study (Munson & Garniewicz 2003) has shown that cooking can severely affect the survival rate for mandibles in the 3-4 months age class. These taphonomic problems have implications for interpretations of archaeologically-derived mortality profiles.

A survey of 74 archaeologically- and ethnoarchaeologically-derived sheep/goat mortality profiles (Munson 2000: Table 1) suggests a fairly consistent equivalence with Payne's predictions. However, some exceptions are notable. One example is that of a modern goat camp where the primary economic emphasis is meat. The percentage of animals slaughtered between two and 12 months is 65% in this case. This percentage agrees well with a milk emphasis when compared to Payne's models, but according to predictions for reliance on meat should be of only 18%. This is an example where demands other than optimization and economic productivity dictate culling decisions. As O'Connor points out (2000:91), certain religious practices or specific demands for lamb skins can sometimes become important factors in decisions about structuring herds. Therefore, interpretations of mortality profiles derived from archaeological data should be treated with caution.

Another critique to Payne's models is that it ignores the economics of meat production and the role of factors related to environmental and market fluctuations in the selection of animals. Comparisons of the models with modern and historic practices show several differences in mortality profiles. In zooarchaeological studies, the optimum age to slaughter sheep and goats for meat is assumed to be between 18 and 30 months (Payne 1973: 282), 21-27 months (Redding, 1981:301), and around 18 months (Dahl and Hjort 1976:207). Economic models, based on growth curves for unmanaged sheep breeds, show that at nine months a lamb weighs more than half of its adult weight (*i.e.*, at 27 months). Delaying its slaughter to 18 and even to 27 months would double and even triple maintenance costs. Modern, ethnographic, and historic literature on offtake practices illustrate that in meat production economies most of the animals not kept as reproductive stock are slaughtered between six and ten months. Similarly, when the production of milk is emphasized, lambs between two and six months are usually slaughtered in large numbers (Munson 2000:396).

Environmental factors also apply. In temperate environments, carrying surplus animals throughout the winter and most herders slaughter at about 6-9 months is costly. In tropical and semi-arid environments, large numbers of animals of both sexes are slaughtered before 15 months. Seasonal variation in prices can strongly affect culling decisions in a market economy, for example, with a strong meat emphasis. Lambs will be slaughtered or sold depending on fluctuations in prices and the degree of financial security of the herder. For example, a lamb sold in spring or early summer (*i.e.*, around 15 months of age) would be worth more than a lamb sold at the onset of winter (*i.e.*, around 6-9 months of age).

The models predict that both sexes will be retained into adulthood in systems where the production of wool is emphasized. Ethnographic and historic examples show that animals are slaughtered earlier than the models predict and that variation in offtake is greater than in meat/milk economies. In other words, substantial offtake in wool economic systems occurs at either 2-3 months, 6-9 months, or 12-15 months. Examples of herders involved in cash economies involving wool export indicate that stable flock sizes can be maintained by retaining only one third of the annual lamb crop (Munson 2000:396, 397). These data contrast with Payne's predictions for wool emphasis, where only a small percentage of animals will be culled at young ages.

In summary, modern, ethnographic, and historic examples of offtake practices suggest that in most meat and/or milk production systems, the offtake of surplus lamb will occur sometime before 12 months of age. Slight variations in the time of slaughter during this interval result from either environmental or market fluctuations. In economies where wool is an important source of income, a substantial offtake of surplus lambs will occur no later than 15 months.

Redding's Mortality Profiles

Redding (1981) developed a series of optimization models to predict subsistence decision making related to herding sheep and goats in the Middle East. His models are derived from studies of modern day pastoralists who maintain unimproved breeds under extensive husbandry. In extensive husbandry systems, sheep and goats are generally kept on natural pastures, with no supplementary feeding, poor control of breeding among reproductives, and no modern veterinary care (Redding 1981:21). These breeds and sets of conditions exhibit parallels to prehistoric ones. Redding predicts variations in three aspects of the herd composition (*i.e.*, sheep/goat ratio, age structure, and adult sex ratio) for a broad range of physical and cultural environments and management systems in the Middle East. In constructing his models, he looks at behavioral and ecological parameters of both small ruminants and human herders. As he points out, the composition of flocks varies along a continuum depending on the degree to which the herders rely on these species for subsistence or market. The extent to which sheep and goat biological requirements are met in a specific physical environment is also an important factor in decision-making.

According to his study, herders structure their flocks either to maximize energy offtake or to assure herd security. If herders are primarily utilizing their flocks for subsistence, then their goal is to extract most easily obtainable nutrients from the animals (*i.e.*, to maximize energy offtake). The herder is thus concerned with optimization of production for subsistence reasons. If the herders are involved in exchange and/or a market economy, then the goal shifts to optimization of herd security. Their concern is to extract animal products with high market value and to minimize fluctuations in resources obtained from the flocks below subsistence needs (Redding 1981:25-26, 46-47). The study does not incorporate predictions for groups that are heavily involved in a market system, for which wool production is an important factor in structuring the flocks.

Figure 17 illustrates expected mortality profiles for the two types of herd strategies. The estimated mortality profile for a caprid flock of 60 ewes and 40 does managed for a maximization of energy offtake is as follows: 22% of the death assemblage die or are slaughtered in the first year, 30% in the second year, and 23% in the third year. The optimal culling strategy focuses on extracting the maximum amount of meat from males between 21 and 27 months. This is the age when optimum weight is attained. In a herd managed with the goal of herd security, around 35% of the death assemblage will be from animals slaughtered in their first year, 27% in their second year, and 13% in their third year. The annual offtake would consist of 60 % males slaughtered between six months and two years and of 40% females of different ages. Higher percentages of females are expected to be retained into early and late adulthood in both models.

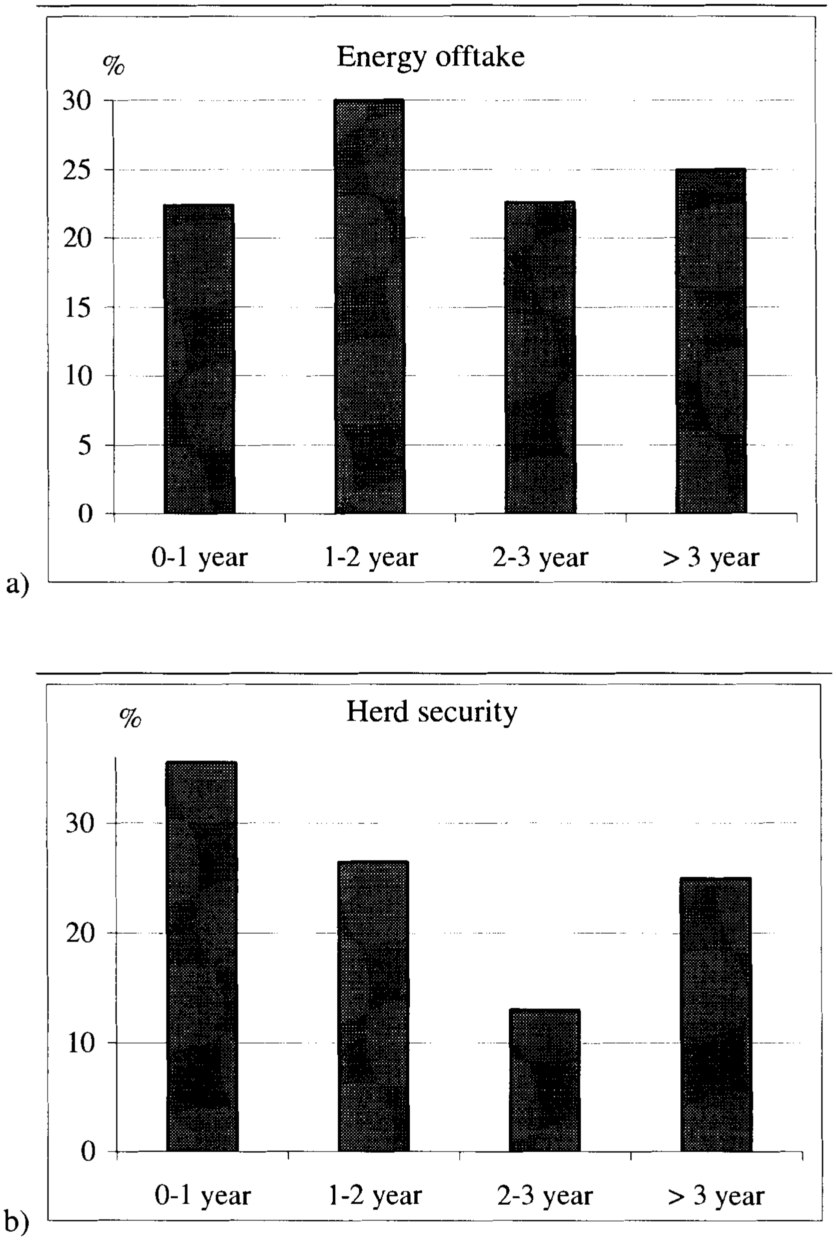

Figure 17. Expected kill-off patterns expressed in percentages of the total death assemblage: a)energy offtake; b)herd security (after Redding 1981:302, 306)

Redding's models have wide applicability and can be used to draw hypotheses and examine flock and herd composition in other parts of the world. However, data on sheep and goat population growth and productivity along with the implications derived from the models, can only be applied to flocks in the Middle East (Redding 1981:383).

Age Profile Methods

Estimations of age at death in the assemblage from Middle Village were based on two sets of data: (1) eruption and attrition dental patterns; and (2) epiphyseal fusion at post-cranial level. The advantages and disadvantages of each of the methods are discussed by different zooarchaeologists (O'Connor 2000; Reitz and Wing 1999; Zeder 1991:92-94). To summarize, tooth eruption data allow us to distinguish between animals in their first year of life (*e.g.*, in the 0-2, 2-6, and 6-12 month ranges). Tooth wear data describe animals into maturity and old age, although accuracy declines with age. Both dental eruption and attrition can be used to age animals throughout their entire lifespan since stages continually change throughout life. One element allows one to estimate age at death, which makes it easier to distinguish individual animals. One drawback of the method is that mandibles with less than two associated teeth in the tooth row cannot be used for age estimations, thus reducing the sample. Secondly, differential treatment of crania from animals of different ages is likely to affect the sample and therefore the age profile. Thirdly, tooth eruption and wear stages are based on observations made on goats kept under extensive conditions and are consequently expected to more closely match ancient goat patterns rather than sheep.

Age data based on long-bone fusion are advantageous for a few reasons: (a) a larger sample is usually recovered; (b) separate sheep and goat age distributions can be obtained since adult elements can be more easily identified to species on the post-cranial skeleton; and (c) differential element butchery and transport is less likely to affect the sample. Although only young mandibles could be identified to species in the past (Payne 1985), new methods have been developed recently to differentiate between adult sheep and goat teeth and mandibles (Halstead *et al.* 2002). Long-bone fusion data present a few problems: (a) individuals cannot be identified once data that include more than one element are combined; (b) specimens do not provide an age estimate, but simply an age range in which the animal died; (c) age estimates cannot be obtained for old animals; and

(d) fusion rates are derived from modern breeds (Silver 1969) that bear few similarities to ancient ones.

Both methods have the disadvantage that relatively few modern studies describe to what degree factors such as type of food eaten, climate, or management practices affect dental eruption and attrition patterns and epiphyseal fusion. Additionally, taphonomic processes preferentially destroy younger specimens.

Principles of Eruption and Tooth Wear Analysis

Teeth erupt at generally predictable ages and as such the eruption sequence of permanent dentition provides a useful tool in estimating age at death. After a permanent tooth is fully erupted, it comes into wear and dental attrition becomes a means to determine age.

Erupting teeth are fully covered by enamel. Once teeth become functional, the enamel on the surface of the tooth starts to wear, exposing the layer of dentine underneath. The relative proportion of enamel to dentine decreases as teeth wear down. Because ovicaprid teeth consist of vertical columns of dentine and enamel, the occusal surface of a worn tooth produces distinctive patterns of enamel and dentine. These varied patterns can indicate age at death (Deniz and Payne 1982; Grant 1982; Zeder 1991). For example, a tooth that shows only the enamel worn with no dentine visible comes from a much younger animal than one with the dentine surface surrounded by an enamel border.

Before moving on to describing the systems used to record caprid dental eruption and attrition stages, several factors affecting dental eruption and wear need to be mentioned. A thorough discussion can be found in Grant (1978) and, more recently in O'Connor (2000). Variability in dental development and attrition is associated with physiological processes, genetic, and environmental factors. Genetic factors affect jaw growth, shape and dental development, and tooth morphology. Among the genotypic related anomalies that can affect tooth wear rates are errors in tooth alignment, malocclusion, tooth rotation, and incorrect angulation (Baker and Brothwell 1980:139).

Several environmentally-related factors that can significantly impact dental development and attrition have also been identified. These include diet deficiencies during the first stages of growth and development, variations in quality and quantity of pasturage, amount and type of soil ingested while grazing, variation in tooth hardness, mastication mode, and regional differences in management practices (Bond and O'Connor 1999; Grant 1978; Healy and Ludwig 1965; Healy *et al.* 1967; Mainland 2003; Silver 1969). For example, softer teeth (usually resulting from excessive fluorine in the water) wear faster than harder ones. Excessive rates of attrition occur when high amounts of abrasive soils (*e.g.*, sand) are ingested. Dental wear can be more rapid for individual teeth in the same tooth row. Some animals show unequal attrition between mandibular sides and between teeth in the same hemiarcade. A premature incisor loss in sheep can also affect mastication and, consequently, tooth wear rates. Differences in eruption and wear sequences between sexes have also been observed (Deniz and Payne 1982). Particularly, rapid or slow wear as a result of differences in management practices are difficult to assess since there is no external evidence to calibrate various datasets (Bond and O'Connor 1999; Grant 1978). Sheep and goats have distinct feeding habits (Redding, 1981) and their attrition patterns are expected to vary accordingly. Eruption times and wear stages for different species of domestic animals have been extensively published (*e.g.*, Bull and Payne 1982; Deniz and Payne 1982; Grant 1982; Grigson 1982; Levine 1982; Payne 1973; Silver 1969; Zeder 1991).

Two standardized systems are commonly used to record caprid mandibular eruption and wear stages. Grant (1982) published diagrams of dental eruption and wear stages for the lower fourth premolars and molars of cattle, sheep, goats, and pigs. With this method, each tooth in a mandible is attributed an eruption or wear stage according to its resemblance to published illustrations. Stages of wear are termed tooth wear stages or T.W.S. and are based on observed patterns of enamel and dentine on the occlusal surface of teeth. Each T.W.S and eruption stage are further assigned a numerical equivalent. The sum of all values in the mandible provides an overall mandible wear stage or M.W.S. After the M.W.S. is derived, mandibles can be placed in rank order. A high M.W.S. is indicative of an older animal, while a lower one of a younger animal. Mandibles can further be grouped in probable relative age classes and histograms based on M.W.S. constructed. If a tooth is missing, its T.W.S. can be predicted by comparing the scores for the other teeth in the mandible. Grant developed tables listing several combinations of scores (T.W.S.) observed on archaeological specimens and that are most likely to occur.

Grant's M.W.S. does not directly provide a conversion to age in months or years and requires specimens to be recorded according to pre-determined categories (O'Connor 2000:87).

The second method was employed by Zeder (1991:92, 93) and is based on a system devised by Payne (1973; see also Deniz and Payne 1982). The method is similar to Grant's in that it classifies mandibular teeth by eruption and wear stages. Through this method, dental wear stages observed on archaeological material can be directly recorded. Each tooth is assigned a score from one to 26 according to its state of eruption or wear (see Zeder 1991: Table 8). Mandibles are assigned an age by comparing the combinations of scores in the tooth row to combinations of scores derived from observations on caprids of known age (Table 27).

Table 27. Mandibular tooth eruption and wear stages for caprids of known age (adapted from Zeder 1991:93, Table 9)

Age class	dP4	P4	M1	M2	M3
2-6 months	01, 09-19	-	04-09	-	-
6-12 months	01, 16-20	-	10-14	02-09	-
1-2 years	01, 19-25	02-08	13-17	11-14	02-08
2-3 years	01,25	02-17	17-19	11-17	02-11
3-4 years	-	16-20	17-25	14-17	12-16
4-6 years	-	20-25	18-26	17	12-17
6-8 years	-	20-25	20-26	18-25	16-17
8-10 years	-	25	25	25	18-25

Lowest scores are equivalent to eruption stages, while highest indicate intense wear. Different combinations of eruption and attrition scores result for each tooth row.. After an age is assigned, a percentage of the total number of mandibles in each age class is computed. These percentages measure kill-off intensity for that particular age class. The method has the advantage of directly converting combinations of scores into age classes and facilitating the recording of wear stages observed on the teeth. For these reasons, this method was employed in this study.

Epiphyseal Fusion

In immature animals, the epiphyses are attached to the diaphysis through a layer of cartilage that allows the bone to grow in length. As animals mature, the cartilage gradually reduces in size until it completely ossifies and the epiphyses become firmly joined to the diaphysis. Elements and element parts in the body fuse at approximately predictable age sequences. If an individual dies when the epiphyses are still connected to the diaphysis through cartilage, the cartilage will decay and the epiphyses will separate from the diaphyses after death. As a result, unfused bones indicate that the animal died prior to the time that fusion for that particular epiphysis occurred. Similarly, if the bone was fused at the time of death, the animal was older than the time when that bone fuses. This kind of information is used to reconstruct age at death from archaeological data. Specifically, information on the number of specimens for which the epiphyses were fused *versus* unfused is extracted. Because the proximal and distal ends of the same element fuse at different developmental stages, complete bones can provide more accurate information on the age at death. However, bones found in archaeological contexts are often disarticulated and fragmentary.

Unlike studies of teeth, where the age of individual animals can be assessed within a likely range, studies of epiphyseal fusion provide less precise data. Variation in the age of fusion is considerable, depending upon sex, breed, and nutritional status. Studies have demonstrated that the age of epiphyseal fusion varies more than the age of tooth eruption (Davis 2000; Hatting 1983). Table 28 summarizes published data on the variation in the time of fusion for different breeds and between sexes (Barone 1976; Davis 2000; Moran & O'Connor 1994; Noddle 1974; Silver 1970).

Improved breeds usually mature earlier than unimproved ones and, as a result, their fusion process is accelerated (Redding 1981; Silver 1970). Studies have also shown that the time of epiphyseal fusion can be delayed by castration (Davis 2000; Hatting 1983; Moran & O'Connor 1994). Specifically, for epiphyses that fuse in the second and third year, castration can delay fusion by approximately one year. Castration does not seem to have a significant impact on dental eruption. Malnutrition can similarly lead to a delay in epiphyseal fusion.

Table 28. Variation in the time of epiphyseal fusion in caprids

Element	Davis 2000	Moran & O'Connor 1994	Smith 1956	Silver 1969	Barone 1976	Noddle 1974			Hatting 1983		
	castrates	castrates	female			female domestic	feral	castrate	female	male	castrate
Proximal radius	< 6	By 11	4	10	3-6	4-9			2-9	<4	12-22
Scapula	< 6	By 11	5	6-8	5-7	9-11	<12	13			
Distal humerus	< 7	By 11	4	10	3-4	11	12-13		2-9	<4	12-22
Second phalanx	< 7		8/6	13-16	6-8	9-11	> 12	13	2-9	5-6	<8
First phalanx	15-25	By 11	10/9	13-16	7-10	11	24	15	2-9	6-13	12-22
Distal tibia	18-25	26-30	15	18-24	12-18	<19	24	>23	13-15	13-30	22-23
Calcaneum	26-30	22-30	15	30-36	36	23	36-48	60	15-23	13-18	23-30
Distal metacarpal	26-30	26-30	26	18-24	16-18	23-30	24-36	>23	15-23	13-18	23-30
Distal metatarsal	27-30	24-30	15	20-28	16-18	23-30	24-36	>23	15-23	13-18	23-30
Proximal ulna	27-31	26-30	21	36	25-35	24-31	48-60	60-84	15-23	13-30	23-30
Proximal femur	31-37	30-36	17-19	30-36	20-26	15	24	23	15-23	13-30	23-30
Distal radius	32-39	32-36	21	36	23-30	23-24	36	60-84	15-31	13-30	> 30
Distal ulna	38-44		26		26-32						
Distal femur	38-48	35-42	18-20	36-42	18-26	23-24	48	60	15-23	13-30	>30
Proximal tibia	38-48	30-42	25	36-42	20-26	23-24	>36	60	15-31	13-30	>35
Proximal humerus	44-52	32-42	27	36-42	25-36	24	36	24	15-31	13-30	>23

Deniz and Payne (1983) argue that in Angora goats differences in the time of epiphyseal fusion between sexes become visible only after the first year. Other authors point to differences in fusion times between domestic and feral animals. Noddle (1974) shows that fusion happens earlier in domestic animals and that feral animals have less exact times of fusion.

Fusion data are generally presented in the form of survivorship curves that show the percentage of animals surviving beyond each age of fusion (*e.g.*, Cavallo 2000; O'Connor 2000; Redding 1981; Zeder 1991). In this study, long-bone survivorship curves were constructed using a classification developed by O'Connor (2000). According to this method, elements are grouped in relative age categories that correspond to their stage of fusion (*i.e.*, early fusing, middle fusing, and late fusing). Then, percentages of fused elements in each age class are computed. The percentage of fused elements in each age class is taken to reflect the proportion of animals surviving beyond that age.

Early fusing elements usually fuse before the age of one year. Late fusing ones are among the last to fuse and more likely come from animals older than three years that have already reached breeding age. Elements in the middle fusing category consist of bones that fuse between the two extremes. As O'Connor points out (2000:95), even if no absolute age is given with this method, by grouping epiphyses that fuse at roughly similar ages, an overall survivorship profile can be obtained. The method has the advantage that percentages of different age categories can be independently calculated.

Middle Village Eruption and Attrition Patterns

Demographic reconstructions on the sample recovered from the Middle Village area of Zuni Pueblo were based on mandibular tooth eruption and attrition states. Individual or lost teeth were not included in the analysis. This way anomalous conditions such as a heavy wear of one tooth compared to the others in the tooth row can be recognized. Left and right elements were compared in order to avoid the counting of mandibles belonging to the same individual twice. The part of the mandible posterior to the second premolar (P3) proved to be most suitable for this investigation.

A total of ninety seven mandibles were attributed to caprids based on dental and morphological criteria (as described in Chapter 3). Forty-five mandibles were diagnosed as ‘sheep’ or ‘possible sheep’, 45 as ‘goat’ or ‘possible goat’, and seven as ‘sheep/goat’. For statistical reasons, mandibles identified as ‘possible sheep’ or ‘possible goat’ were added to either the ‘sheep’ or ‘goat’ categories. Teeth were assigned eruption and wear scores following Zeder’s diagrams (1991: Table 8). Scores and their correspondent age classes are shown in Appendix C. When two age ranges were suggested for the same mandible, the range to which most of the teeth fell was used. A few mandibles displayed abnormal wear of the fourth premolar and first molar, usually accompanied by alveolar resorption. Because this might have accelerated the wear rate for the other teeth in the mandible, these mandibles were excluded from the analysis. In some instances, age attribution was uncertain because of missing or broken teeth. In total, eight mandibles were left aside. Generally, the mandibles from Zuni Pueblo fit Zeder’s categories well, showing results that are consistent with hers.

Figure 18 a and b present bivariate plots of eruption and wear scores for combinations of teeth from Zuni. The patterns suggest that both eruption and wear are more rapid during early stages of growth (from stage 4 to 12), then the tooth stays in stages 12 to 16 for a long time, and then wear becomes rapid again in old age. Teeth could transfer from stages 16 through 24 in a very short period of time, which is not very informative about age. For both M1 and M2, wear is more pronounced in stage 17.

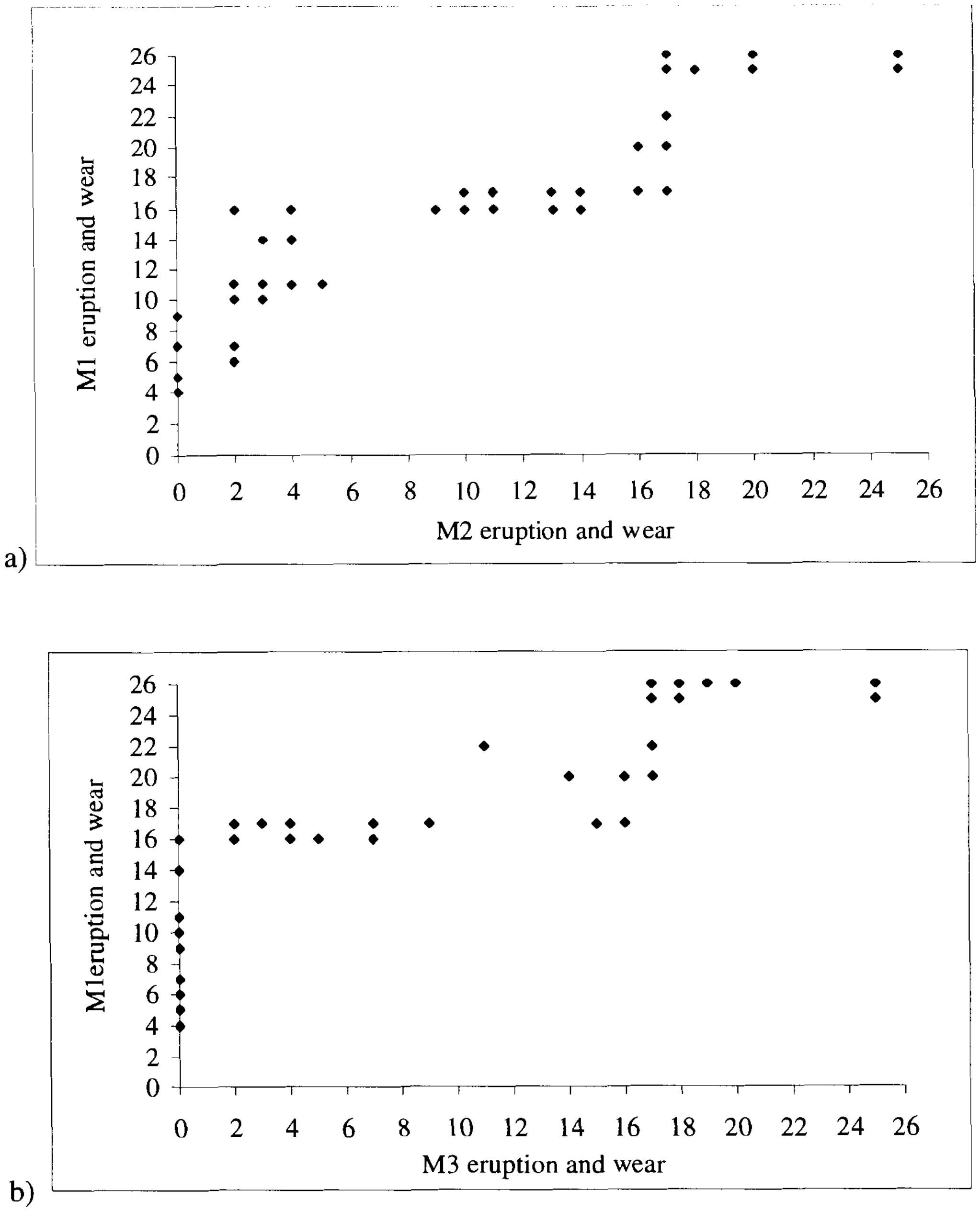

Figure 18. Bivariate plots of eruption and wear data at Zuni Pueblo, Middle Village

General Mandibular Age Distributions

Separate age distributions for the two caprid species as well as for the whole assemblage are illustrated in Table 29 and Figure 19. Data are presented as percentages of the total population of mandibles in the death assemblage. As different researchers point out (*e.g.*, Halstead *et al.* 2002; Redding 1981), sheep and goats differ in many aspects related to their environmental tolerance, feeding preference, reproductive pattern, range of secondary products, and productivity just to name a few. Consequently, distinctions in management strategies between these two species should be expected.

Table 29. Zuni tooth eruption/wear age distributions

Age	Ovis		Capra		Ovis/Capra*	
	N	%	N	%	N	%
2-6 months	7	15.90	0	0	8	8.98
6-12 months	6	13.63	9	23.07	16	17.97
1-2 years	15	34.09	10	25.64	26	29.21
2-3 years	2	4.54	3	7.69	5	5.61
3-4 years	4	9.09	7	17.94	13	14.60
4-6 years	5	11.36	4	10.25	10	11.23
6-8 years	3	6.81	3	7.69	6	6.74
8-10+ years	2	4.54	3	7.69	5	5.61
Number of bones	44		39		89	

* sums sheep, goat, and sheep/goat

The individual sheep and goat mortality profiles shown here are tentative because mandibles identified as 'possible sheep' could be goats and *vice versa*. This analysis is intended to demonstrate that by using the combined category (*i.e.*, sheep/goat), differences in management strategies between the two species may be obscured. Indeed, individual sheep and goat distributions indicate dissimilarities in the utilization of the two species. Generally, both species are slaughtered with different intensities throughout their entire life span and both young and older animals are used. Data do not indicate any utilization/or natural death of sheep prior to two months and of goats younger than six months. As previously mentioned, mandibles in these age classes are fragile and poorly preserve archaeologically. Carnivore damage is not extensive in the assemblage and therefore is not expected to be responsible for this pattern. The absence of these age classes may also indicate neonatals or young animals that do not survive during their travel from pastures to permanent camps. Very young animals were probably neither selected for slaughter nor brought to the village.

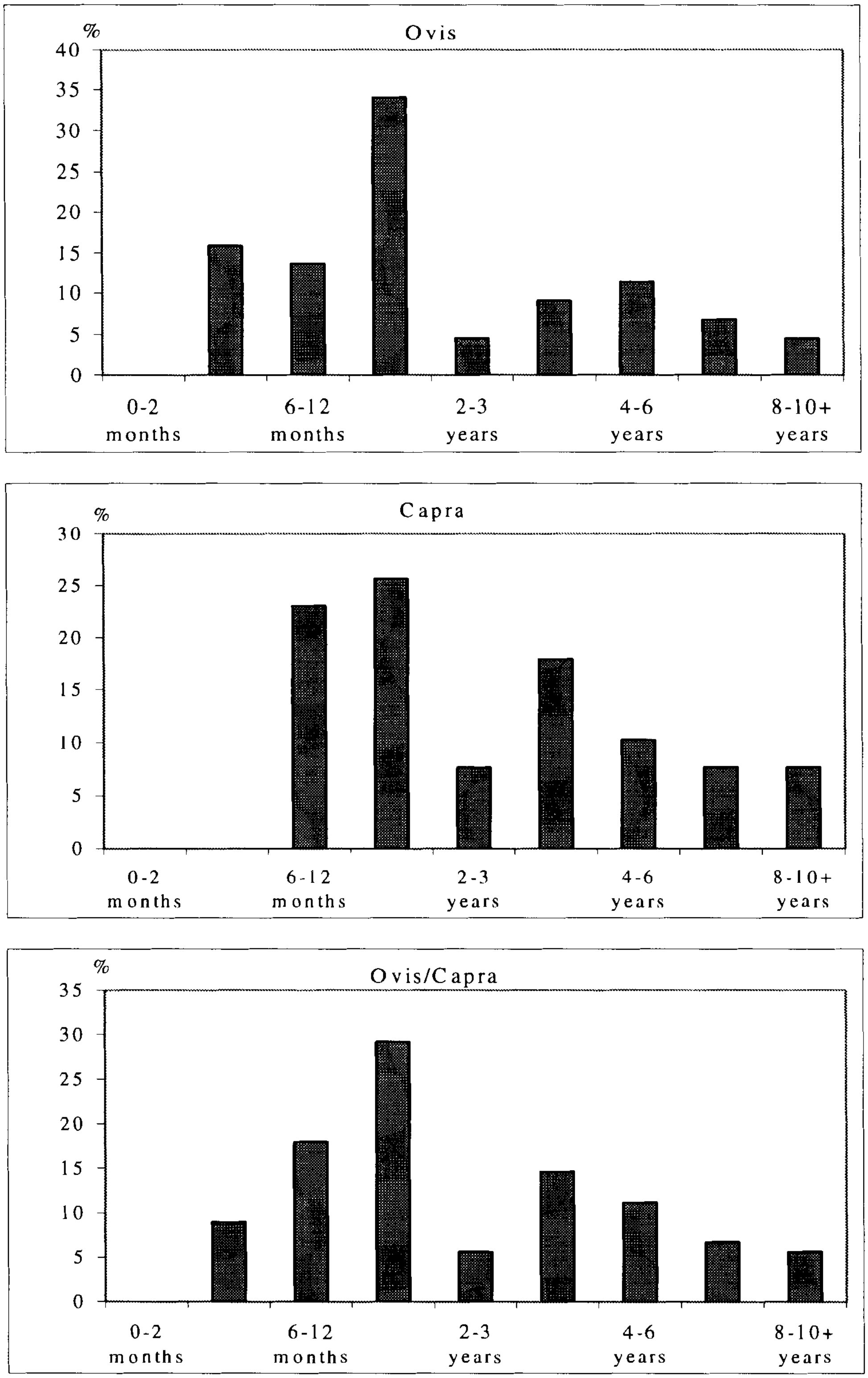

Figure 19. Zuni general mandibular kill-off pattern (expressed in percentages of the death assemblage)

A marked focus on culling both caprid species in their first and second year of life is apparent. Almost equal proportions of sheep are slaughtered in the 2-6 and 6-12 months age ranges. The kill-off for sheep peaks at 34% in the one to two years range, drops to lower than 5% in the two to three years class, slightly increases between three and six years and then drops again. As for goats, more animals seem to be retained and slaughtered with higher intensities in maturity than sheep. Goats are also intensely culled between six months and two years. More goats seem to be slaughtered in the three to four year range than sheep. A combined mortality profile, which pools all mandibles (*i.e.*, sheep + goat + sheep/goat), suggests that the offtake is relatively low in the zero to one year age range, peaks in the one to two year range, drops at its lowest in the two to three year range, slightly increases between three and six years, and then drops again.

When mandibles in the zero to one year range are grouped together, a selection of young animals becomes even more evident (Figure 20). Almost 64% (N=28) sheep, and 49% (N=19) goats are culled between two months and two years of age. Higher percentages of sheep slaughtered in this age range may be related to the fact that sheep provide more meat and more calories per edible portion than goats (Redding 1981:103; Dahl and Hjort 1976:170). On average, 56% (N=50), both sheep and goats, are slaughtered during this interval. Culling drops substantially between two and three years and percentages in this age class are lowest for both species (around 6% in average). Sheep and goats continue to be slaughtered, but at lower rates after three years of age. The goat kill-off shows a second peak at 3-4 years, while sheep at 4-6 years. This could indicate a selection of animals for which productivity and reproductive values have diminished.

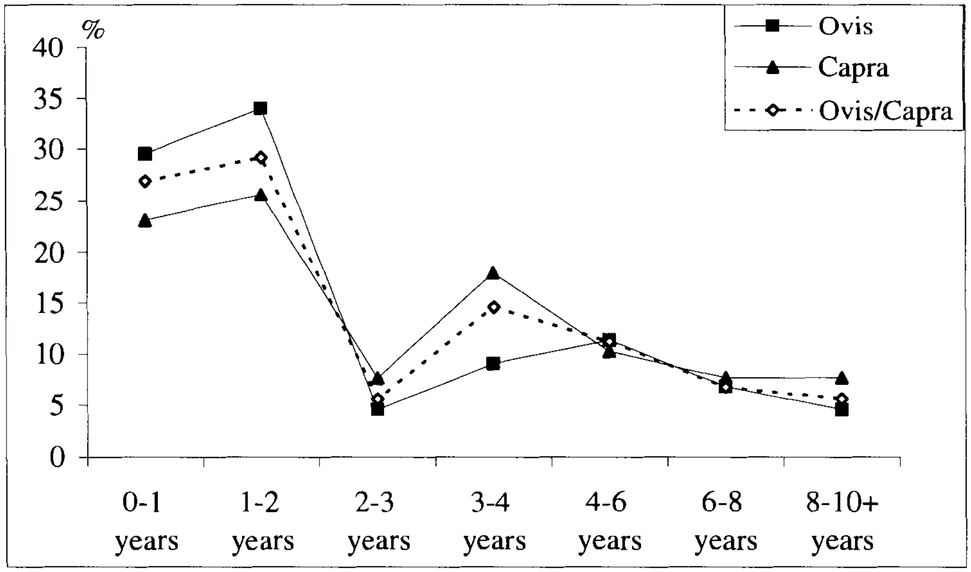

Figure 20. Comparative mandibular age distributions for the two species of caprids

Chronological Mandibular Distributions

Changes in herd management through time were explored by classifying the mandibles in temporal sub-assemblages. Chronological distributions by species based on raw data are presented in Appendix C. Six caprid mandibles were dated to Late Prehistoric, 26 to Mission, five to Post-Revolt, and 28 to Late Historic times. A total of thirty-two mandibles could not be chronologically assigned. Some sheep/goat mandibles were dated to the Late Prehistoric Period. Domesticates were not part of the local fauna in Late Prehistoric times and, as previously mentioned, bioturbation and the movement of sediments might have been responsible for this phenomenon. Consequently, these mandibles, along with those that could not be dated were not used in derivations of kill-off profiles. Two mandibles from Mission and two from Late Historic contexts were also excluded from the analysis because they either displayed abnormal wear and pathologies or their age assignment was uncertain. The Post-Revolt sample was too small to provide an indication of the culling pattern and was also eliminated from this analysis. Similarly, due to sample size considerations, sheep and goat mandibles were grouped together in the samples from Mission and Late Historic Periods. A detailed chronological analysis is presented in Table 30.

Table 30. Zuni *Ovis/Capra* dental age distributions through time

Age Class	Mission		Late Historic		Not dated *	
	N	%	N	%	N	%
0-2 months	0	0	0	0	0	0
2-6 months	1	4.16	3	11.53	4	11.76
6-12 months	6	25.00	6	23.07	4	11.76
1-2 years	5	20.83	10	38.46	10	29.41
2-3 years	3	12.50	2	7.69	0	0
3-4 years	6	25.00	2	7.69	4	11.76
4-6 years	3	12.50	3	11.53	4	11.76
6-8 years	0	0	0	0	4	11.76
8-10+ years	0	0	0	0	4	11.76
Number of mandibles	24		26		34	

Note: * includes mandibles assigned to Late Prehistoric

During the Mission Period, the intensity of killing is higher in the 6-12 month and 3-4 year ranges, while in the Late Historic Period, an increase in slaughtering in the 1-2 year range is apparent. This pattern is accompanied by a decrease in the proportions of animals older than two years, particularly of animals in the two to four year ranges. Note that the absence of animals older than six years is the result of the fact that mandibles in this range have been excluded because they present abnormal degenerative patterns.

When data from the age classes in the zero to one year ranges are pooled, differences in culling strategies through time are even more distinct (Figure 21). The sample from Mission shows two peaks of mortality: one in the 0-1 year range and the second in the 3-4 four year range. The peak of culling at 3-4 years is the consequence of goat mandibles prevalence in this age class and does not probably reflect a sheep strategy (see Appendix C). In the Late Historic Period, an increase in animals slaughtered around 1-2 years is apparent. Slaughtering declines substantially in the two to three year range, reaches a hiatus up to four years, slightly peaks again in the four to six year range, and then drops again.

This sample includes more mandibles identified as sheep and is probably more likely to reflect sheep husbandry practices. During both time periods, selective culling of sheep in the zero to two year age classes is indicated, although with different intensities.

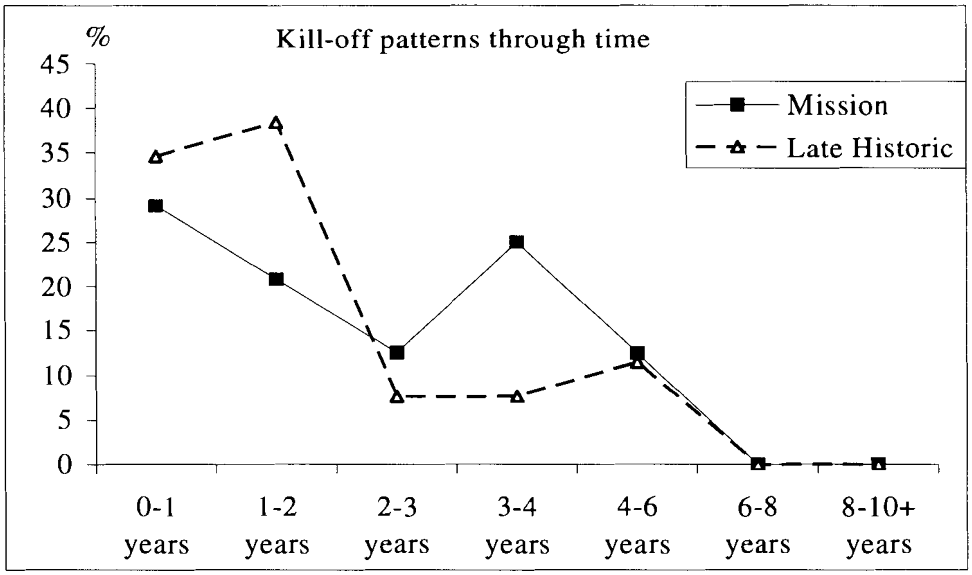

Figure 21. Comparative mandibular kill-off patterns through time

If the results are compared to the models of herd management strategies presented at the beginning of the chapter (Figure 22 a, b), the slaughtering patterns seem to strongly suggest a meat emphasis as predicted by Payne, where animals, probably males, are slaughtered once their growth curve begins to decline. However, a wool-based herd management strategy, as described in Zuni historic and ethnographic accounts, (*e.g.* Benedict 1959; Crampton 1977; Cushing 1920; 1979; Eggan 1950; Stevenson 1904; Tedlock 1992; Webster 1997, 2000, 2003) and in modern examples (Munson 2000) cannot be excluded. Modern examples show that in economies based on a strong wool emphasis, stable flock sizes can be maintained by retaining only one third of the annual lamb production. Most lambs are therefore slaughtered either at the onset of winter (around nine months) or spring (around 12 months), but not later than 15 months of age (Munson 2000:397). The culling patterns at Zuni are in accord with Redding's predictions for a flock managed for herd security. This strategy generally involves culling the male surplus (around 52.4%) between six months and two years. At Zuni, 46% in Mission and 61% in Late Historic were culled within this age range.

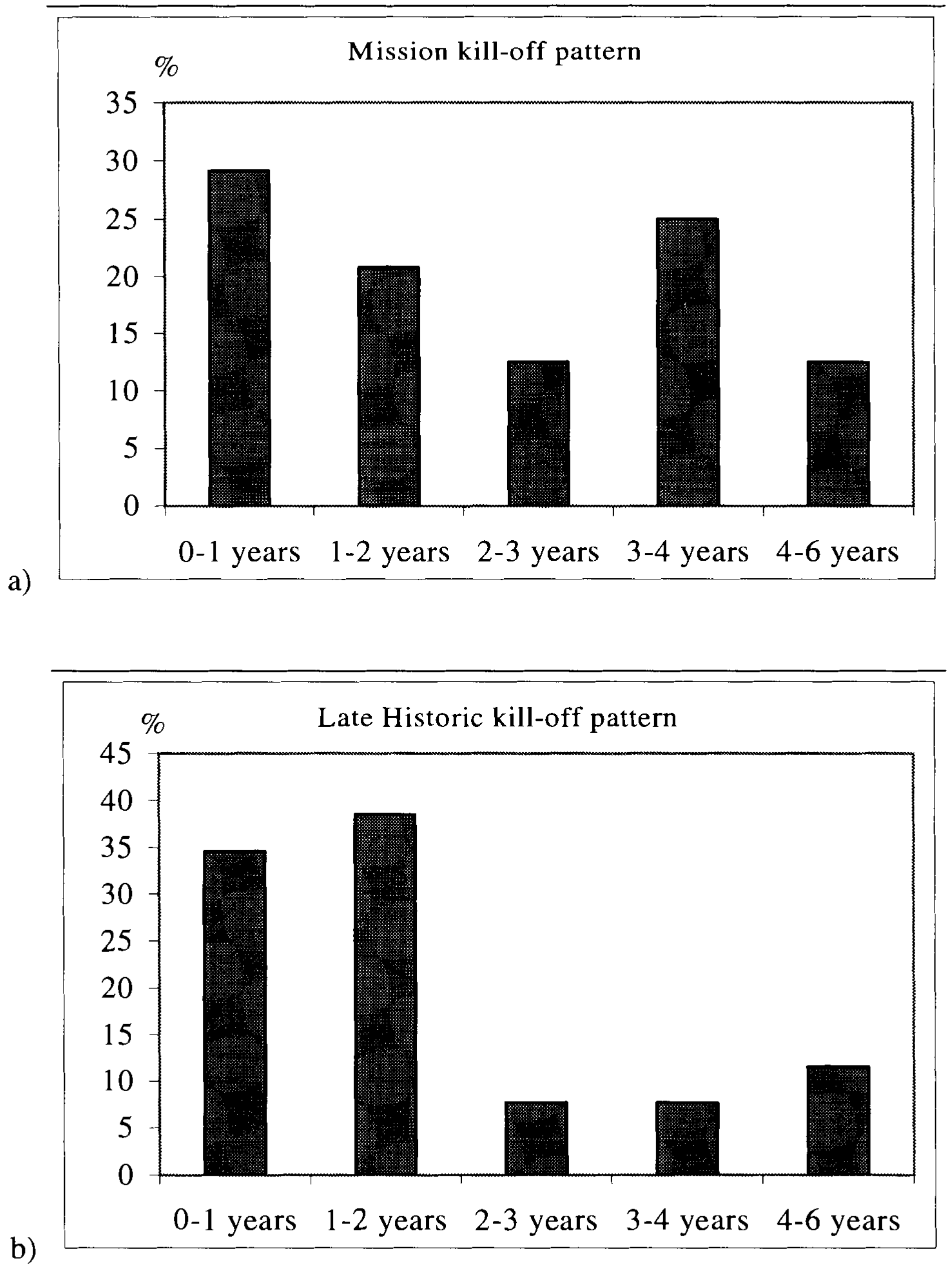

Figure 22. Kill-off patterns through time

Since mandibles cannot be sexed at this time, concluding that, in fact, males were slaughtered and females retained is not possible. On the other hand, in market economies, herders generally export surplus sub-adult males (Olsen 1982). Consequently, sub-adult males may be missing from the archaeological record, but data are technically limited at this point to provide information on sex structure.

A pattern where animals are slaughtered at 2-3 years, the age at which males attain maximum meat weight, is not observed. The Missionaries exported sheep and Pueblo-made textiles and blankets to the mines in northern New Mexico in order to support the missions (Hackett 1937; Kelly 1941; Simmons 1979a; Webster 2003). If animals were exported by the Missionaries, then animals in the 2-3 year range might represent the population (*i.e.,* on foot), probably males, that are less represented in the archaeological record. In both phases, the distributions suggest that animals are culled when their growth curve starts to level off, as early as nine months. This may involve both economic and environmental considerations. If lambs are born in February-March, then the majority of lambs are killed prior to the onset of winter during the Mission Period. In the Late Historic period, a small proportion of lambs were culled before winter, while the major portion of them the following spring or early summer. This is more in accord with large-scale wool producing economies (Munson 2000:397). Higher proportions of animals killed in the one to two year range in Late Historic time might be also related to increased ceremonial activities at Zuni Pueblo. Ethnographic sources indicate that thousands of lambs and sheep were slaughtered during ceremonies throughout the year, and especially during the Shalako (Cushing 1920; Stevenson 1904).

According to recent management practices at the Pueblo of Laguna, breeding is controlled and males are kept at a different location until the reproductive season (Cattle *et al.* 1981). Consequently, these profiles might also imply that a proportion of the reproductive males in the 2-3 year range might be herded somewhere else, at least during Late Historic times. Currently available data on mandibular caprid mortality profiles from both Mission and Late Historic Periods suggest that risk aversion was of primary concern in structuring the flocks.

Middle Village Fusion Data

Chronological Age Distributions Based on Fusion Data

A chronological distribution of long-bone samples and fusion states are presented in Appendix C. One problem with the construction of survivorship curves from archaeological data lies in the difficulty in separating certain elements of wild artiodactyls. As Redding points out (1981:319), if bones of wild artiodactyls are present in the assemblage, the survivorship curve is not likely to reflect the management of domestic species. Many unfused bones could not be identified to species because they lack distinct morphological landmarks and were included into a larger category, of indeterminate 'deer-pronghorn-caprinae'. Proportions of fused to unfused bones are shown in Table 31 and Figure 23 a and b.

Table 31. Proportions of fused to unfused elements through time

Chronology	Sheep/Goat				Deer sized artiodactyls			
	Fused		Unfused		Fused		Unfused	
	N	%	N	%	N	%	N	%
Mission	341	71.9	133	28.1	23	18.8	99	81.2
Post-Revolt	112	67.0	55	33.0	2	3.77	51	96.2
Late Historic	581	62.8	344	37.2	32	8.06	365	91.9

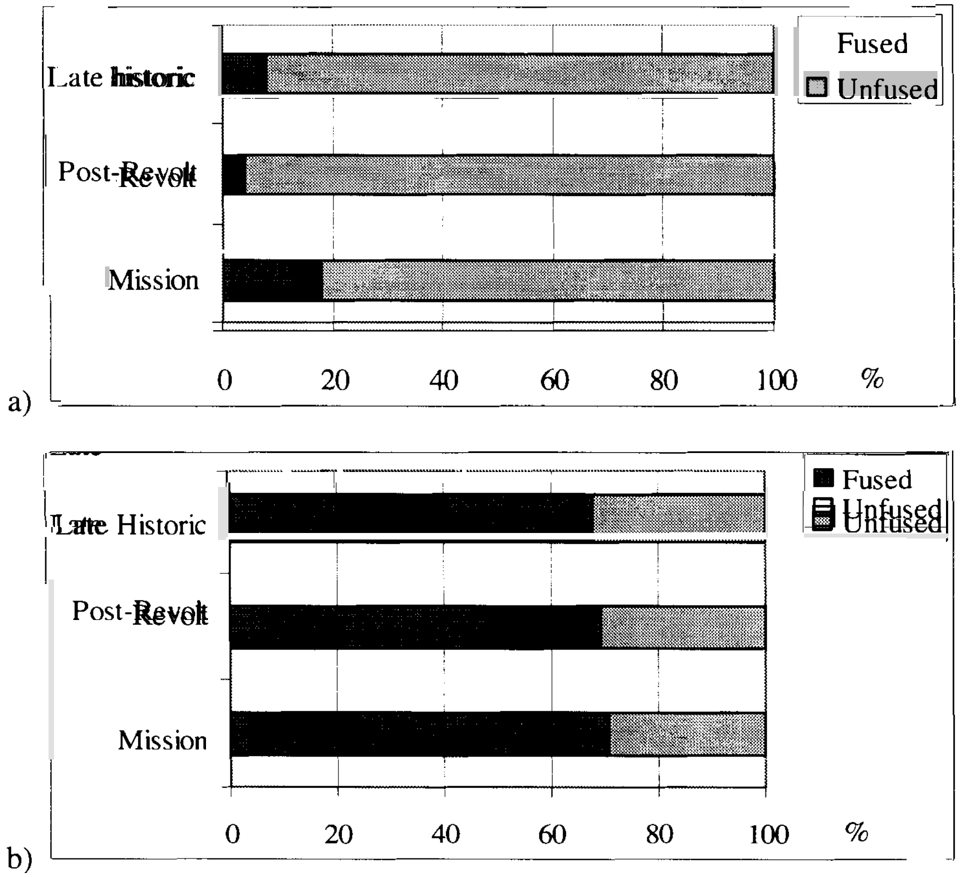

Figure 23. Proportions of fused to unfused elements through time: a) deer size artiodactyls; b) sheep/goat

This distribution shows that most unfused bones fall in the indeterminate deer-size category, while most fused elements were identified as sheep/goat. In order to avoid over-counting, unfused epiphyses were matched with their associated daiphyses whenever possible. Long-bones used in the sheep/goat differentiation were grouped in age classes, depending on their approximate age of fusion and fusion stage. Percentages of fused bones in each age group were further computed. Chronological distributions of sheep/goat survivorship patterns are shown in Table 32 a, b, c. As expected, all temporal assemblages display a decline in the percentages of fused bones as the age at fusion increases. This indicates that the assemblage was not seriously affected by poor preservation of unfused specimens.

Table 32 a. Mission – *Ovis/Capra* fusion distribution

Epiphysis	Number fused	Number unfused	% fused	Approximate age of fusion
Scapula distal	21	6		
Humerus distal	13	2		
Radius proximal	11			
Total early 1	**45**	**8**	**84.9**	6-10 months
Phalanx 1 proximal	103	55		
Phalanx 2 proximal	94	10		
Total early 2	**197**	**65**	**75.19**	13-16 months
Tibia distal	10	6		
Metapodium distal	54	36		
Calcaneus proximal	8	7		
Total medium	**72**	**49**	**59.5**	18-28 months
Radius distal	8	8		
Ulna proximal	7	4		
Humerus proximal	2	1		
Femur proximal	4	12		
Femur distal	3	4		
Tibia proximal	2	5		
Total late	**26**	**34**	**43.33**	36-42 months

Table 32 b. Post-Revolt – *Ovis/Capra* fusion distribution

Epiphysis	Number fused	Number unfused	% fused	Approximate age of fusion
Scapula distal	7	1		
Humerus distal	5	3		
Radius proximal	14			
Total early 1	**26**	**4**	**86.67**	6-10 months
Phalanx 1 proximal	24	18		
Phalanx 2 proximal	26	6		
Total early 2	**50**	**24**	**67.56**	13-16 months
Tibia distal	6	3		
Metapodium distal	10	7		
Calcaneus proximal	6	7		
Total medium	**22**	**17**	**56.41**	18-28 months
Radius distal	2	5		
Ulna proximal	5	4		
Humerus proximal	1	2		
Femur proximal	3	5		
Femur distal	2	4		
Tibia proximal	0	3		
Total late	**13**	**23**	**36.11**	36-42 months

Table 32 c. Late Historic – *Ovis/Capra* fusion distribution

Epiphysis	Number fused	Number unfused	% fused	Approximate age of fusion
Scapula distal	43	10		
Humerus distal	47	16		
Radius proximal	58	1		
Total early 1	**148**	**27**	**84.57**	6-10 months
Phalanx 1 proximal	124	96		
Phalanx 2 proximal	104	42		
Total early 2	**228**	**138**	**62.29**	13-16 months
Tibia distal	31	29		
Metapodium distal	37	38		
Calcaneus proximal	42	47		
Total medium	**110**	**114**	**49.10**	18-24 months
Radius distal	24	45		
Ulna proximal	20	30		
Humerus proximal	6	13		
Femur proximal	19	14		
Femur distal	16	25		
Tibia proximal	10	11		
Total late	**95**	**138**	**40.77**	36-42 months

The ages at which some of the epiphyses fuse overlap and makes it difficult to distinguish more precise patterns as was possible with the mandibles. Overall, a gradual increase of animals killed at young age (*i.e.*, before 18-28 months) through time is shown in fusion data. Specifically, the decline in the zero to two year range varies from about 38% during Mission, to 44% during Post-Revolt, and to 48% during Late Historic. Similarly, a gradual increase in animals slaughtered in the one to two year range is apparent. Declines in percentages in this age class fluctuate between 25 % in Mission, to 40% in Post-Revolt, and to around 45% in Late Historic times. Note that the upper limit of each age range is taken as reference in these calculations.

The increase in the percentages of animals killed at 1-2 years during Late Historic times is accompanied by a slight decrease in percentages of animals slaughtered before one year. The 3-4 year peak of mortality, identified with the mandibles from Mission, was not recognized in the fusion data. This might correlate with the fact that most mandibles in this age class were identified as goats, while long-bone data contain a high proportion of elements identified as sheep (see Appendix C). Offtake in the 2-3.5 year range is low in all phases. Proportions vary from 13% and 14% in Mission and Post-Revolt, to about 7% in Late Historic. This pattern corroborates well with the pattern suggested by the mandibles. Generally, the age distributions based on fusion data correlate well with the mandibles and a comparison between the two data sets is illustrated in Figure 24 a and b.

The mandibular survivorship curve was calculated by subtracting the percentage of kill-off in the first age class from 100 percent, then subtracting the percentage of kill-off in the second age class from the remainder and so on. Survivorship curves based on fusion data were derived from percentages of fused elements in each specific age class. As Zeder points out (1991:94), fusion and dental age distributions cannot be compared on a 'one-to-one' basis and an exact match of the two data sets cannot be expected. Mandibular distributions reflect a percentage of animals derived from the total population of mandibles, while fusion data a percentage of fused bones out of the elements in an age class category. Despite the imprecision of fusion data, the two distributions show analogous patterns of slaughtering. Most obvious is the increase in the intensity of culling in the 1-2 year range during the Late Historic era. Similarly, a decrease in the percentages of animals killed in the 2-3 year range through time is apparent in both distribution curves.

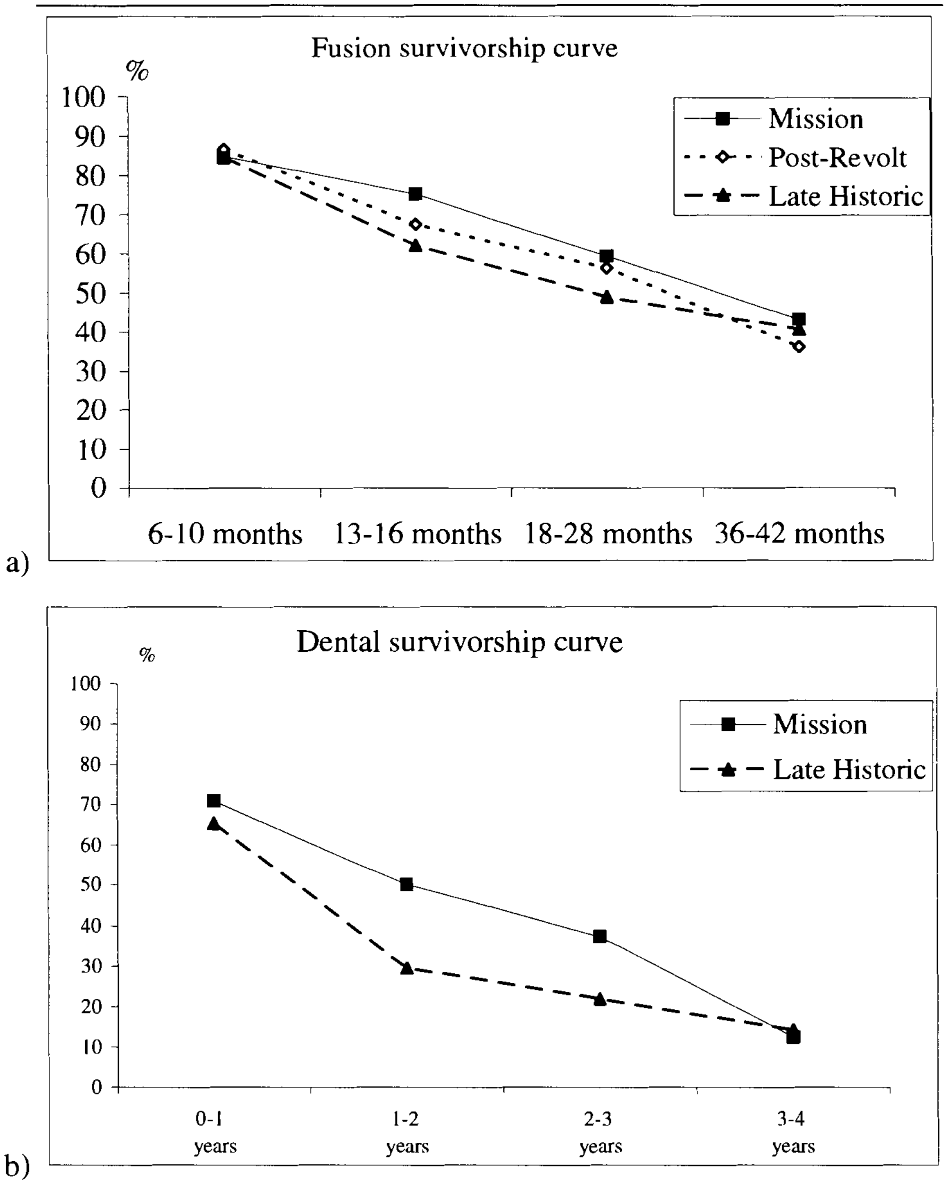

Figure 24. *Ovis/Capra* survivorship curves through time: a) fusion; b) dental

Because many unfused bones fell in the indeterminate deer-size artiodactyl category, the proportions of fused elements were recalculated including all deer size artiodactyls (*i.e.*, sheep/goat + deer/pronghorn + indeterminate deer-size artiodactyls). New distributions are shown in Tables 33 a, b, c. Patterns that are similar to the sheep/goat data, namely, an increase in the percentages of animals killed before two years of age through time are apparent. Specifically, there is an increase of animals slaughtered in this age range, from 54% animals during Mission to 66% during each of the Post Revolt and Late Historic eras. A decrease in the proportions of animals killed between two and three and half years is similarly suggested. Percentages in this age range fluctuate from 17% during Mission, to 11% during Post Revolt and 10% during Late Historic times. The proportion of animals killed at 1-2 years increases with circa 14% from Mission to Late Historic. Because more unfused bones are included in the late fusing category than for sheep/goat, the deer size distribution indicates lower percentages of animals surviving after three and a half years.

Table 33 a. Mission – fusion distribution for all deer sized Artiodactyls

Epiphysis	Number fused	Number unfused	% fused	Approximate age of fusion
Scapula distal	23	6		
Humerus distal	14	3		
Radius proximal	13	3		
Total early 1	**50**	**12**	**80.6**	6-10 months
Phalanx 1 proximal	108	52		
Phalanx 2 proximal	96	8		
Total early 2	**204**	**60**	**77.2**	13-16 months
Tibia distal	11	16		
Metapodium distal	61	66		
Calcaneus proximal	9	10		
Total medium	**81**	**92**	**46.8**	18-28 months
Femur proximal	4	16		
Radius distal	8	11		
Ulna proximal	8	6		
Humerus proximal	3	9		
Femur distal	4	15		
Tibia proximal	2	11		
Total late	**29**	**68**	**29.8**	36-42 months

Table 33b. Post-Revolt – fusion distribution for all deer size Artiodactyls

Epiphysis	Number fused	Number unfused	% fused	Approximate age of fusion
Scapula distal	7	1		
Humerus distal	5	0		
Radius proximal	15			
Total early 1	**27**	**1**	**96.4**	6-10 months
Phalanx 1 proximal	24	13		
Phalanx 2 proximal	27	5		
Total early 2	**51**	**18**	**73.9**	13-16 months
Tibia distal	6	10		
Metapodium distal	10	23		
Calcaneus proximal	6	9		
Total medium	**22**	**42**	**34.3**	18-28 months
Radius distal	2	8		
Ulna proximal	5	7		
Humerus proximal	1	6		
Femur proximal	3	12		
Femur distal	2	5		
Tibia proximal	1	7		
Total late	**14**	**45**	**23.7**	36-42 months

Table 33c. Late Historic – fusion distribution for all deer size Artiodactyls

Epiphysis	Number fused	Number unfused	% fused	Approximate age of fusion
Scapula distal	45	17		
Humerus distal	52	14		
Radius proximal	61	5		
Total early 1	**158**	**36**	**81.4**	6-10 months
Phalanx 1 proximal	126	94		
Phalanx 2 proximal	104	27		
Total early 2	**230**	**121**	**65.5**	13-16 month
Tibia distal	37	59		
Metapodium distal	42	120		
Calcaneus proximal	42	49		
Total medium	**121**	**228**	**34.6**	18-28 month
Radius distal	24	74		
Ulna proximal	22	38		
Humerus proximal	6	44		
Femur proximal	25	53		
Femur distal	17	63		
Tibia proximal	10	52		
Total late	**104**	**324**	**24.2**	36-42 months

Figure 25 illustrates a survivorship curve for all deer-size artiodactyls. Although minor differences from the sheep/goat patterns are observed, the general trends remain the same. Concluding that, in fact, this distribution more likely reflects sheep/goat herding is difficult since most of the unfused elements are included in the indeterminate deer size artiodactyl category of identification. Until bones of juveniles can be identified to species, this analysis remains preliminary.

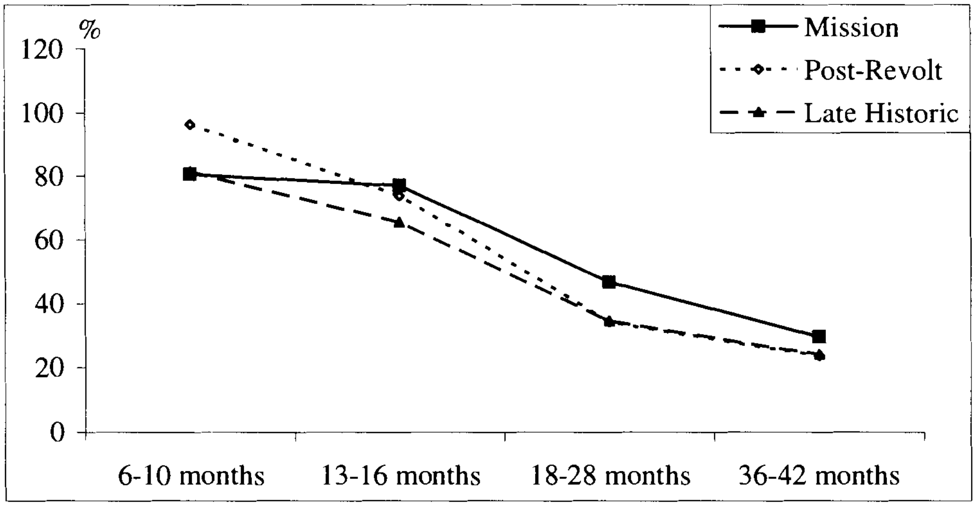

Figure 25. Survivorship curve for all deer size artiodactyls through time

Chapter Summary

Caprid mandibular eruption and attrition patterns along with epiphyseal fusion data were employed to derive mortality profiles for the archaeological assemblage from the Middle Village area of Zuni Pueblo. The patterns of slaughtering derived from mandibular and epiphyseal fusion data, although very general, do not suggest that the temporal variation is associated with differences in taphonomic histories or differences in sample size. The patterns, particularly in the case of fusion, seem to be related to identification since most unfused elements cannot be identified to species.

Profiles were further compared to models and ethnographic and modern examples of herd strategies for interpretations. Data on animal ages do not support concrete conclusions at this time, but they present us with a picture of how the flocks were herded after contact. The interpretations of the age at slaughter provide evidence of temporal variation in herd management. Most notable are the differences between the samples from Mission and Late Historic periods. During the time of the Spanish Missionaries, sheep and goats were culled more homogenously, although with different intensities throughout their life span. Higher percentages were slaughtered in their first and fourth year. This slaughtering pattern mainly suggests a mixed economy. Sheep and goats were not raised solely for meat, but also kept for by-products. During the Late Historic period, the culling strategy shifts to slaughtering younger animals, particularly in their second year of life. This slaughtering pattern correlates well with a strong emphasis on meat as predicted by the models. Since this area of the site is intimately connected to Zuni ceremonial manifestations, the archaeological record might be the result of a deposition where animals are slaughtered for consumption related to ritual practices. However, the pattern also correlates with modern and ethnographic data on herd management in economies that strongly emphasize wool production. In these examples, surplus lambs are slaughtered not later than 15 months. Large numbers of animals were killed during ceremonies at Zuni each year and these animals might represent surplus. The two interpretations are interconnected, since both ritual and wool production purposes can be accommodated using the same strategy. Analyses of slaughtering patterns in other area of Zuni Pueblo are essential to elucidate the nature of this deposition.

This information has important implications for interpreting the development of a market-oriented animal husbandry in Zuni area. The choices of when to slaughter animals were based on Spanish interests for export during Mission and on Zuni ceremonial practices and/or wool textile export during Late Historic times. Meat preservation problems, among other cultural factors, influenced seasonal slaughtering patterns. The high level of demand for wool textiles could also have exerted a strong influence on the appropriate scheduling of slaughtering.

CHAPTER 6

DEER-SIZE ARTIODACTYLS: BUTCHERY AND BODY PARTS

Introduction

This chapter examines diachronic body-part distributions and butchery patterns for the deer-size artiodactyl group. The first section discusses skeletal element frequencies and body-part representations, while the second part butchery patterns as reflected by tool marks on bones. Skeletal element frequencies are examined in light of recovery rates, while body-part representations of comparisons to standard distributions. Since body-part representations are strongly influenced by post-depositional destruction, the effect of potential taphonomic forces on skeletal element distribution is assessed. The basic approach for the reconstruction of carcass division relies on butchery mark frequencies at specific locations on individual bones and body parts. Ethnic affiliations are examined through both butchery and skeletal portion analyses.

The study of butchery and body part representations continues to be an important topic in the zooarchaeological literature (*e.g.*, Albarella 1997; 2003; Bartram *et al.* 1991; Blumenschine & Marean 1993; Capaldo 1997; Domingo-Rodriguez 1999, 2003; Landon 1997, 1997; Lupo and O'Connell 2002; Lyman 1977, 1987; Reitz and Scarry 1985; Schultz and Gust 1983; Zeder 1991). Frequencies of skeletal elements and skeletal portions have been widely used in studies of butchery patterns, body-part utility and differential transport, special activity areas, social organization, ethnicity, and exchange (Binford 1978, 1981; Crabtree 1990; Klein *et al.* 1999; Landon 1996; Lyman 1994; Outram 2001; Reitz and Scarry 1985; Stiner 1994, 2002). In the context of selective transport, White (1953b) and Perkins and Daly (1968) proposed that body-part distributions in archaeological assemblages provide a useful tool for drawing inferences about human utilization of carcasses and decision making.

Body-part quantifications were customarily applied to studies of hunter-gatherers in an attempt to identify foraging patterns and early hominid behavior (e.g., Bartram and Marean 1999; Binford 1978, 1981; Dominguez-Rodrigo 1999; Klein *et al.* 1999; Lupo and O'Connell 2002; Outram 2001; Perkins and Daly 1968; Rogers and Broughton 2001; Stiner 1994). Similarly, skeletal frequencies and body-part representations were variously and comprehensively employed to interpret animal exploitation in urban *versus* rural contexts (*e.g.*, Zeder 1991; Landon 1996, 1997) or social status (*e.g.*, Crader 1990; Reitz 1987; Schultz and Gust 1983). The underlying assumption in studies of body-part is that carcass acquisition, transport, processing habits, and ritual activities will produce variation in skeletal frequencies in zooarchaeological collections (Bartram and Marean 1999; Binford 1978, 1981; Klein *et al.* 1999; Marshall and Pilgram 1991; Outram 2001; Rogers and Broughton 2001; Stiner 1994, 2002; White 1953).

Skeletal frequencies and body-part representations are subject to pre- and post-depositional taphonomic destruction, both cultural and natural (Lyman 1994; Payne 1972; Reitz 1986: Stiner 2002). Mechanical processes that affect bones include scavenging by carnivores, weathering or water transportation, crushing by sediments or trampling, and marrow processing by humans just to name a few. Carnivore damage by removing or chewing bones was widely discussed (*e.g.*, Binford 1981; Marean *et al.* 1992; Marean and Spencer 1991; Munson 2002). Recent actualistic studies show that cooking methods employed can also strongly impact element frequencies (Munson and Garniewicz 2003). However, human and natural processes can interact to create more complex patterns than those seen in controlled experiments.

Skeletal Frequencies

As discussed in Chapter 2, minimum number of elements (MNE) and recovery rates (RR) were employed in derivations of skeletal frequencies and body-part profiles in the diachronic data set from the Middle Village. MNE derivations per element are presented in Appendix D.

There is a growing literature on how MNE values should be obtained (*e.g.*, Bartram 1993; Bartram and Marean 1999; Bunn and Kroll 1986; Klein and Cruz-Uribe 1984; Klein *et al.* 1999; Outram 2001; Marean and Spencer 1991; Stiner 1994, 2002). Debates primarily focus on whether shaft fragments should be included in MNE computations along with articular ends. According to experimental and ethnoarchaeological research, carnivores typically focus on epiphyses because of their high grease content and softness (Blumenschine & Marean 1993; Marean & Spencer 1991; Marean *et al.* 1992). Because carnivore damage is not significant in the assemblage and interpretations of marrow utilization are not a concern here, articular end frequencies were computed in the analysis of body parts. Another reason that led to the choice of epiphysis-based MNE counts for limbs was that the analysis was undertaken for the deer-size artiodactyl group and species identification within this group was based on a large number of articular ends. Shaft fragments are not readily identifiable to species and were therefore included in a general category, of indeterminate 'deer-pronghorn-caprinae'. The ratio of articular ends to shafts is approximately 12:1 (based on NISP; counts do not include phalanges, witch were complete in most cases).

The analysis of body-part distributions was further complicated by the fact that some of the bones have very similar characteristics (*e.g.*, axial elements) and, as a result, were difficult to identify to species. Distinguishing ribs and vertebrae fragments of sheep and goat from deer and pronghorn is particularly difficult. Consequently, combined analyses for all deer-size artiodactyls accompany separate examinations of sheep/goat and deer/pronghorn patterns.

In order to alleviate problems related to differential distribution of elements in the body, MNE raw counts were standardized prior to being employed in comparisons at intra-specific level (*cf.* Stiner 1994:254). Table 34 shows the number of element frequency in the body. Standardized MNE values (or sMNE) per anatomical element and region were obtained by dividing raw MNE values by the number of element frequency (or NEF), that is, the number of times a specific element occurs in the body.

Potential Taphonomic Biases in the Middle Village Assemblage

In order to examine the degree of disparity in the assemblage, observed/expected ratios (*cf.* O'Connor 2000:72-73) and recovery rates (*cf.* Landon 1996:141) were calculated. The formula used to derive recovery rates is as follows: RR=MNE/E(MNI), where MNE is the minimum number of elements, E is the expected number of a specific element in one individual, and MNI is the bone-based minimum number of individuals for a specific taxon (Crader 1984:86; Landon 1996:141). MNI is derived by dividing the highest MNE in the sample by the number of times that specific skeletal portion occurs in the skeleton.

Table 34. Deer-size Artiodactyl expected MNE values (*i.e.,* standard) by skeletal element and by anatomical region (adapted from Stiner 1994:244, Table 9.4)

NEF by anatomical element		NEF by anatomical region	
Element	**Number**	**Region**	**Number**
Horn/Antler	2	Horn	2
1/2 Mandible	2		
1/2 Skull	2	Head	4
Atlas	1		
Axis	1	Neck	7
Other Cervical vertebra	5		
Thoracic vertebra	13		
Lumbar vertebra	7		
Caudal	5	Axial	60
Sternum	7		
Rib	26		
Innominate	2		
Scapula	2	Upper Front	4
Humerus	2		
Radius	2		
Ulna	2	Lower Front	18
Carpals	12		
Metacarpal	2		
Femur	2	Upper Hind	2
Tibia	2		
Calcaneum	2		
Astragalus	2	Lower Hind	16
Other Tarsals	8		
Metatarsal	2		
First Phalanx	8	Foot	24
Second Phalanx	8		
Third Phalanx	8		
Totals	137		137

The highest MNE serves as an estimate of the number of carcasses represented in the assemblage. This calculation is the same as the '*percent survivorship*' (Lyman 1994:256).

Raw data and derived computations are presented in Tables 35 a, b, c. The 'observed' values used are the modified counts or standardized MNE values (*i.e.,* sMNE= MNE/NEF). These modified counts were divided by an 'expected' value (E_1) representing the mean modified count per element if all elements were equally represented in the assemblage. E_I is calculated by dividing the sum of sMNE-s by the number of elements listed. For example, in Table 35 a, the sum of sMNE-s, 1103.87 is divided by 28 (the total number of elements listed), resulting in an E^1 value of 39.42. Each standardized MNE in the sMNE column is further divided by E_I. Data are filtered by calculating the mean and the standard deviation for the sMNE/E_I column and then observing for which elements the sMNE/E_I ratio lies more than one standard deviation below or above the mean (*cf.* O'Connor 2000:72). Generally, these elements are particularly informative about potential destructive biases in the assemblage.

In order to further understand the degree of destruction and preservation of different element parts in the assemblage, recovery rates (RR%) were compared to density-mediated survival percentages (SP) for bones of animals of different ages (six and 90 months) (Binford 1981:218, Table 5.04). Sheep/goat and deer/pronghorn skeletal distributions include mostly fused elements and, therefore, RR% are compared to Binford's SP estimates for animals of 90 months (see Tables 35 a and b). Similarly, because the majority of the unfused elements are included in the indeterminate category, RR% for all deer-size artiodactyls are compared to SP estimates for each of the two age categories (see Table 35 c).

One interesting feature in the assemblage is that a complete range of wild and domestic artiodactyls portions is represented, suggesting that both groups were exploited in this area of the site. Overall, we note a scarcity of small elements (such as carpals, tarsals, distal ulna) and of cancellous element parts (*e.g.*, proximal tibia, proximal femur, proximal humerus). The under-representation of small elements is usually a consequence of sullegic factors (*i.e.*, recovery biases). Porous, soft ends, on the other hand, are more susceptible to destruction by scavengers before burial and later post-depositional taphic processes. Low representations of cranium are the product of a high degree of fragmentation of cranial elements. Skulls were more vulnerable to destruction because they were baked in ovens and intensely processed for brain extraction at Zuni (Olsen 1982).

Table 35a. Sheep/Goat skeletal element distribution

Element	MNE	sMNE	sMNE/E_1	RR %	SP 90 m
Horn Core (2)*	29	14.5	***0.37***	19.5	N/A
Cranium (2)	13	6.5	***0.16***	***8.7***	100.0
Mandible (2)	97	48.5	1.25	65.5	100.0
Atlas (1)	39	39	1.01	52.7	73.2
Axis (1)	38	38	0.98	51.3	47.5
Scapula (2)	141	70.5	**1.83**	95.3	100.0
Proximal Humerus (2)	28	14	***0.36***	18.9	19.1
Distal Humerus	118	59	1.53	79.7	100.0
Proximal Radius (2)	107	53.5	1.38	72.2	100.0
Distal Radius (2)	76	38	0.98	51.3	76.9
Proximal Ulna (2)	51	25.5	0.66	34.4	100.0
Distal Ulna (2)	18	9	***0.23***	***12.1***	76.9
Carpals (12)	93	7.75	***0.20***	***10.4***	51.2
Proximal Metacarpus (2)	147	73.5	**1.90**	**99.3**	35.3
Distal Metacarpus (2)	118	59	1.53	**79.7**	43.2
Innominate (2)	77	38.5	0.99	***52.0***	100.0
Proximal Femur (2)	59	29.5	0.76	***39.8***	76.97
Distal Femur (2)	48	24	0.62	32.4	51.21
Proximal Tibia (2)	29	14.5	***0.37***	19.5	47.24
Distal Tibia (2)	85	42.5	1.10	***57.4***	100.0
Astragalus (2)	111	55.5	1.44	75.0	80.0
Calcaneus (2)	126	63	**1.63**	85.1	87.6
Tarsals (8)	120	15	***0.38***	***20.3***	84.0
Proximal Metatarsal (2)	110	55	1.42	**74.3**	43.4
Distal Metatarsal (2)	135	67.5	**1.75**	**91.2**	32.1
First Phalanx (8)	432	54	1.40	**72.9**	21.0
Second Phalanx (8)	300	37.5	0.97	**50.7**	15.0
Third Phalanx (8)	205	25.62	0.66	**34.6**	11.0
Total		1078.37			
E_1 (=Total/28)		38.51			
Standard deviation of sMNE/E^1		0.53			
± 1σ range		0.47-1.53			

Note: * number of times a skeletal part occurs in one individual; sMNE = standardized MNE; RR = recovery rate; elements for which the sMNE/E_1 ratio lies more than one standard deviation above the mean are in bold; elements for which the ratio lies less than one standard deviation below the mean are in italics bold; SP 90m = expected survival percentage for animals aged 90 months; RR % higher than SP expected are in bold; RR % lower than SP expected are in italics bold

In the sheep/goat distribution, the scapula and the proximal and distal metatapodials (metacarpals and metatarsals) are over-represented. These epiphyses survive destructive forces well. Smaller or more fragile, less dense elements (*e.g.*, carpals, tarsals, distal ulna, cranium, proximal humerus, and proximal tibia) are present in less than expected abundances. As portrayed by the recovery rates percentages (RR%), dense elements such as the mandible, scapula, distal humerus, and proximal radius have greater than 70% recovery in the assemblage. Other elements with fairly good survival rates such as the atlas, axis, astragalus, and calcaneus are also characterized by high recovery rates. Proximal metacarpus and scapula display the highest recovery rates (over 95%).

Most of the limb bones have RR higher than 50% with a few exceptions: proximal and distal femur, proximal tibia, proximal ulna, and proximal humerus. Under-representation of these element parts is to some extent related to identification because a large number of unfused elements or epiphyseal fragments could not be identified to species and were included in the indeterminate deer-size artiodactyl category (notice the increase in RR% for these element parts in Table 35 c). It is also related, as previously discussed, to their high amount of cancellous bone that makes them attractive to scavengers.

Studies of survival rates of different body parts show that the distal metacarpal has a greater survival rate than the proximal metacarpal, while the proximal and distal metatarsal have fairly close survival percentages (Binford 1981:218; Landon 1996:54). The RR% are fairly close in each of the two groups and the over-representation of the proximal metacarpus is probably not attributable to taphonomic biases.

Although the variation in the deer/pronghorn assemblage is undoubtedly related to taphonomic and recovery biases, one important pattern is apparent, which is an over-representation of scapulae (see Table 35 b). The scapula is a high meat-bearing element that survives post-depositional processes well and can be easily identified to species. Binford argues (1981:274) that "assemblages dominated by upper limb elements are generally second-order assemblages. That is, they represent a selection of parts from a population already strongly biased away from the proportions characteristic of a living animal."

Table 35b. Deer/Pronghorn skeletal element distribution

Element	MNE	s MNE	s MNE/E_1	RR %	SP 90 m
Antler (2)*	12	6	1.21	31.5	N/A
Cranium (2)	8	4	0.80	***21.0***	100.0
Mandible (2)	9	4.5	0.91	***23.7***	100.0
Atlas (1)	2	2	0.40	***10.5***	73.2
Axis (1)	3	3	0.60	***15.8***	47.5
Scapula (2)	38	19	**3.84**	100.0	100.0
Proximal Humerus (2)	7	3.5	0.70	18.4	19.1
Distal Humerus	14	7	1.41	***36.8***	100.0
Proximal Radius (2)	13	6.5	1.31	***34.2***	100.0
Distal Radius (2)	10	5	1.01	***26.3***	76.9
Proximal Ulna (2)	16	8	1.61	***42.1***	100.0
Distal Ulna (2)	4	2	0.40	***10.5***	76.9
Carpals (12)	16	1.33	***0.26***	***7.0***	51.2
Proximal Metacarpus (2)	7	3.5	0.70	18.4	35.3
Distal Metacarpus (2)	11	5.5	1.11	28.9	43.2
Innominate (2)	8	4	0.80	***21.0***	100.0
Proximal Femur (2)	4	2	0.40	***10.5***	76.97
Distal Femur (2)	5	2.5	0.50	***13.1***	51.21*
Proximal Tibia (2)	12	6	1.21	31.5	47.24*
Distal Tibia (2)	14	7	1.41	***36.8***	100.0
Astragalus (2)	7	3.5	0.70	***18.4***	80.0
Calcaneus (2)	8	4	0.80	***21.0***	87.6
Tarsals (8)	18	2.25	0.45	***11.8***	84.0
Proximal Metatarsal (2)	11	5.5	1.11	28.9	43.4
Distal Metatarsal (2)	7	3.5	0.70	18.4	32.1
First Phalanx (8)	63	7.87	1.59	41.4	21.0
Second Phalanx (8)	43	5.37	1.08	28.2	15.0
Third Phalanx (8)	33	4.12	0.83	21.7	11.0
Total		138.44			
E^1(=Total/28)		4.94			
Standard deviation of sMNE/E^1		0.67			
± 1σ range		**0.33-1.67**			

Note: * number of times a skeletal part occurs in one individual; sMNE = standardized MNE; RR = recovery rate; elements for which the sMNE/E_1 ratio lies more than one standard deviation above the mean are in bold; elements for which the ratio lies less than one standard deviation below the mean are in italics bold; SP 90m = expected survival percentage for animals aged 90 months; RR % higher than SP expected are in bold; RR % lower than SP expected are in italics bold

Table 35c. All deer size artiodactyl (sheep/goat + deer/pronghorn + indeterminate) skeletal element distribution

Element	MNE	s MNE	s MNE/E_1	RR %	SP 6 m	SP 90 m	Mean of 6+90 m
Antler / Horn core (2)*	41	20.5	***0.42***	18.8	N/A	N/A	N/A
Cranium (2)	**22**	**11**	***0.22***	***10.0***	81.8	100.0	94.0
Mandible (2)	**106**	**53**	**1.09**	***48.6***	100.0	100.0	100.0
Atlas (1)	**44**	**44**	**0.90**	40.3	24.7	73.2	58.0
Axis (1)	**46**	**46**	**0.94**	42.2	35.6	47.5	44.0
Cervical (5)	**155**	**31**	**0.63**	28.4	35.6	35.1	35.0
Thoracic (13)	**242**	**18.6**	***0.38***	***17.0***	33.7	43.6	40.0
Lumbar (7)	**305**	**43.57**	**0.89**	40.0	33.7	59.6	51.0
Caudal (5)	**41**	**8.2**	***0.16***	7.5	N/A	N/A	N/A
Sternum (7)	**13**	**1.8**	***0.03***	12.0	N/A	N/A	N/A
Rib (26)	**520**	**20**	***0.41***	18.3	35.0	24.6	28.0
Scapula (2)	**217**	**108.5**	**2.23**	99.5	45.5	100.0	82.0
Proximal Humerus (2)	**72**	**36**	**0.74**	33.0	0	19.1	10.0
Distal Humerus (2)	**160**	**80**	**1.65**	73.3	41.5	100.0	81.0
Proximal Radius (2)	**136**	**68**	**1.40**	62.3	37.1	100.0	80.0
Distal Radius (2)	**127**	**63.5**	**1.31**	58.2	24.7	76.9	60.0
Proximal Ulna (2)	**139**	**69.5**	**1.43**	63.7	37.1	100.0	80.0
Distal Ulna (2)	**29**	**14.5**	***0.29***	***13.3***	24.7	76.9	60.0
Carpals (12)	**113**	**9.41**	***0.19***	***8.6***	3.98	51.2	36.0
Proximal Metacarpus (2)	**166**	**83**	**1.71**	**76.1**	20.3	35.3	30.0
Distal Metacarpus (2)	**162**	**81**	**1.67**	**74.3**	38.1	43.2	47.0
Innominate (2)	**125**	**62.5**	**1.28**	***57.3***	37.1	100.0	80.0
Proximal Femur (2)	**126**	**63**	**1.29**	57.7	19.1	76.97	58.0
Distal Femur (2)	**98**	**49**	**1.01**	44.9	35.1	51.21	46.0
Proximal Tibia (2)	**93**	**46.5**	**0.95**	42.6	28.9	47.24	41.0
Distal Tibia (2)	**160**	**80**	**1.65**	73.3	19.1	100.0	74.0
Astragalus (2)	**123**	**61.5**	**1.26**	56.0	7.7	80.0	57.0
Calcaneus (2)	**151**	**75.6**	**1.55**	69.2	25.4	87.6	68.0
Tarsals (8)	**141**	**17.6**	***0.36***	***16.1***	16.9	84.0	62.0
Proximal Metatarsal (2)	**138**	**69**	**1.42**	**63.3**	25.4	43.4	38.0
Distal Metatarsal (2)	**151**	**75.5**	**1.55**	**69.2**	25.4	32.1	30.0
First Phalanx (8)	**507**	**63.37**	**1.30**	**58.1**	12.6	21.0	17.0
Second Phalanx (8)	**347**	**43.37**	**0.89**	**39.7**	12.6	15.0	14.0
Third Phalanx (8)	240	30	0.61	**27.5**	12.6	11.0	12.0
Total		1648.02					
E^1(=Total/34)		**48.47**					
STDEV of s MNE/E^1		**0.55**					
± 1σ range		0.45-1.55					

Note: * number of times a skeletal part occurs in one individual; sMNE = standardized MNE; RR = recovery rate; elements for which the sMNE/E_1 ratio lies more than one standard deviation above the mean are in bold; elements for which the ratio lies less than one standard deviation below the mean are in italics bold; SP = density mediated survival probabilities (percentages) for sheep from Binford (1981:218; Table 5.04); SP - expected values for animals of 6 months, 90 months, and the mean of 6 and 90 months per bone are presented; RR % higher than SP expected are in bold; RR % lower than SP expected are in italics bold

When RR% are compared to SP, more than half of the element parts are under-represented. This suggests that the patterns observed are most likely the result of identification since many unfused elements could not be identified to species. The overall representation for all deer-size artiodactyls (including sheep/goat, deer/pronghorn, and indeterminate deer-size artiodactyls) matches the patterns expected (see mean SP values), based on differential bone robusticity and fusion sequences. Deviations from expected distributions are very similar to those previously discussed for the sheep/goat group. Combined patterns of skeletal part distribution by group based on RR% are illustrated graphically in Figure 26.

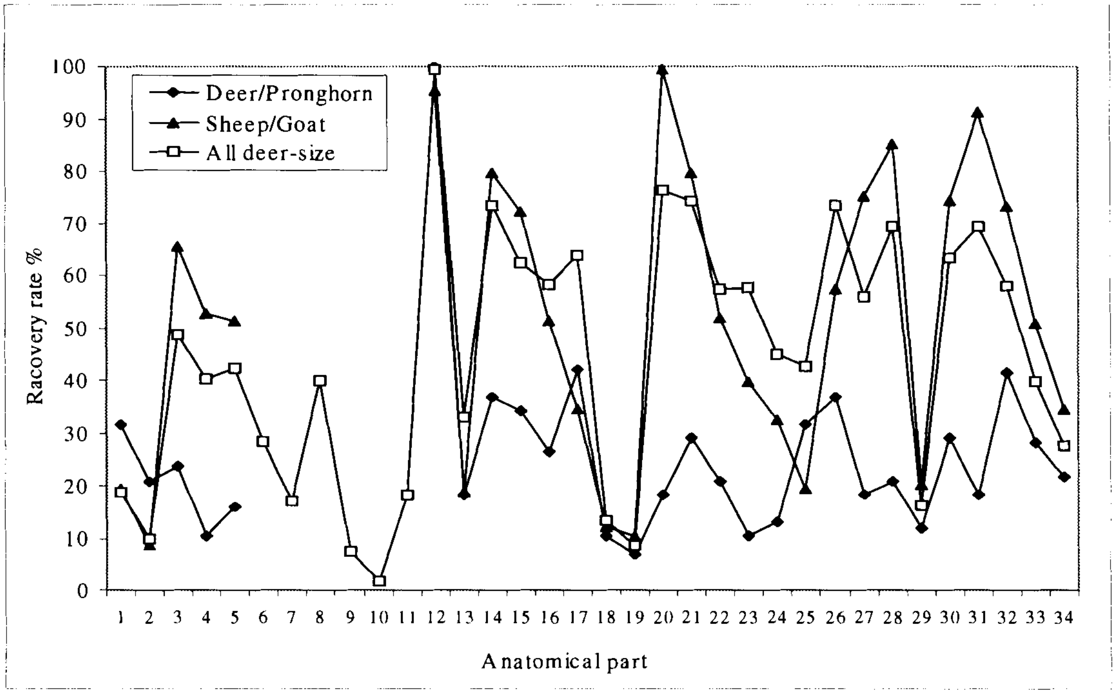

Figure 26. Recovery rates by group

Body part designations are as follows: 1) antler/horn core; 2) cranium; 3) mandible; 4) atlas; 5) axis; 6) other cervical; 7) thoracic; 8) lumbar; 9) caudal; 10) sternum; 11) rib; 12) scapula; 13) proximal humerus; 14) distal humerus; 15) proximal radius; 16) distal radius; 17) proximal ulna; 18) distal ulna; 19) carpals; 20) proximal metacarpal; 21) distal metacarpal; 22) innominate; 23) proximal femur; 24) distal femur; 25) proximal tibia; 26) distal tibia; 27) astragalus; 28) calcaneum; 29) other tarsals; 30) proximal metatarsal; 31) distal metatarsal; 32) proximal phalanx; 33) medial phalanx; 34) distal phalanx

Figure 27 illustrates a combined frequency distribution including all deer-size artiodactyl groups, based on sMNE/E^1 ratios. The distribution indicates more or less similar patterns of disparity in the three assemblages with the exception being the deer/pronghorn scapula.

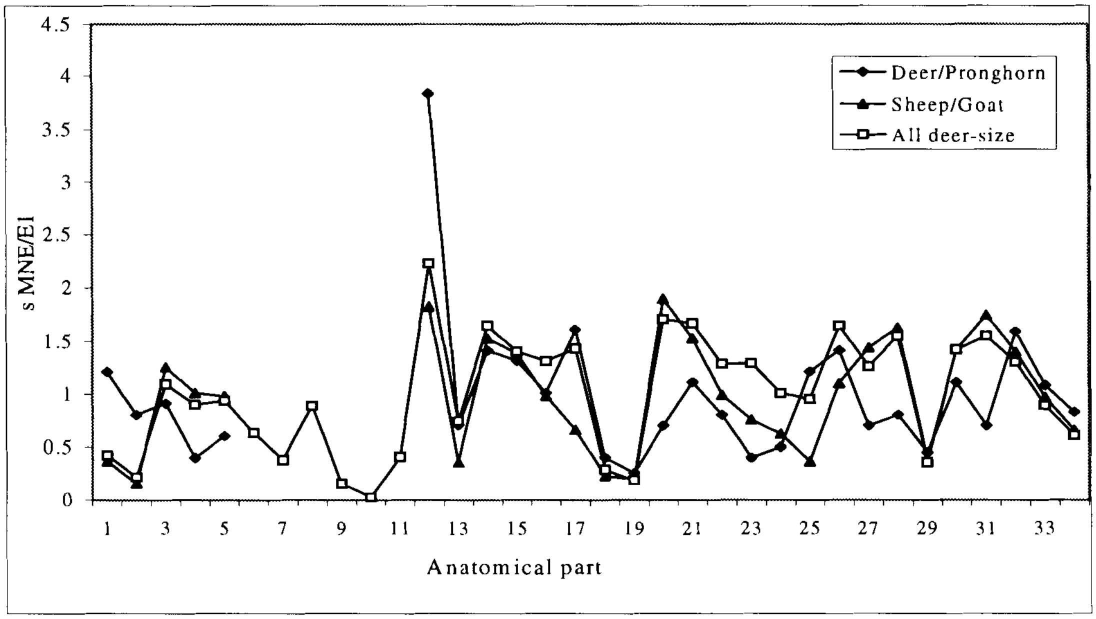

Figure 27. Observed/Expected distribution by group

Body part designations are as follows: 1) antler/horn core; 2) cranium; 3) mandible; 4) atlas; 5) axis; 6) other cervical; 7) thoracic; 8) lumbar; 9) caudal; 10) sternum: 11) rib; 12) scapula; 13) proximal humerus; 14) distal humerus; 15) proximal radius; 16) distal radius; 17) proximal ulna; 18) distal ulna; 19) carpals; 20) proximal metacarpal; 21) distal metacarpal; 22) innominate; 23) proximal femur; 24) distal femur; 25) proximal tibia; 26) distal tibia; 27) astragalus; 28) calcaneum; 29) other tarsals; 30) proximal metatarsal; 31) distal metatarsal; 32) proximal phalanx; 33) medial phalanx; 34) distal phalanx

Bone destruction from different mechanical processes is a condition of the mineral component (*i.e.*, structural resistance) of bone tissue. Bone density-mediated destruction is discussed elsewhere (*e.g.*, Binford 1981; Binford and Bertram 1977; Brain 1981; Lyman 1984, 1994). Because bone density varies between elements of the same species and between species, different bone density data are applied for each species (*e.g.*, Kreutzer 1992; Lyman *et al.* 1992; Stahl 1999). In a recent study, Lam *et al.* (2003) argued that the lack of consensus in the methodology employed to derive bone mineral density indices can lead to differences in density data between species. These disparities can be erroneously interpreted as species-specific variation when, in fact, they are a methodological consequence. The most common methodology used to derive bone mineral density data is photon densiometry. As Lam *et al.* (2003) point out, this method underestimates bone mineral density in areas where internal cavities are present (*e.g.*, shafts). Post-depositional density-mediated attrition in the Zuni assemblage was assessed by comparing the abundance of skeletal element parts (MNE/NEF) to bone density values developed by Lyman (1994:246-247). Because derived bone density values for shaft scan sites were not included in this analysis, this method was considered appropriate. The bivariate scattergram plot (Figure 28) shows a low statistical correlation between element frequency and bone density ($r = 0.33$, $P = 0.11$). Furthermore, the $r^2=0.10$ value suggests that only 10% of the variability in element frequencies is related to bone density. Generally, this implies that the observed variability in element frequencies is more probably a consequence of cultural selection rather than natural diagenesis (Grayson 1989; Lyman 1985). However, if the two outliers in the plot (scapula - topmost and distal ulna - bottom right) are excluded from the analysis, the dispersal clearly indicates a statistically significant correlation between bone density and element frequency, with relatively denser elements being predominant in the assemblage ($r = 0.61$, $P = 0.002$). This suggests that natural attrition had indeed affected the assemblage to some degree ($r^2=0.37$; note that the difference between the two r-squares is of 27%). Consequently, the low representation of distal ulnae is more likely the result of recovery biases, while the over-representation of scapulae result from factors other than natural diagenesis, probably cultural.

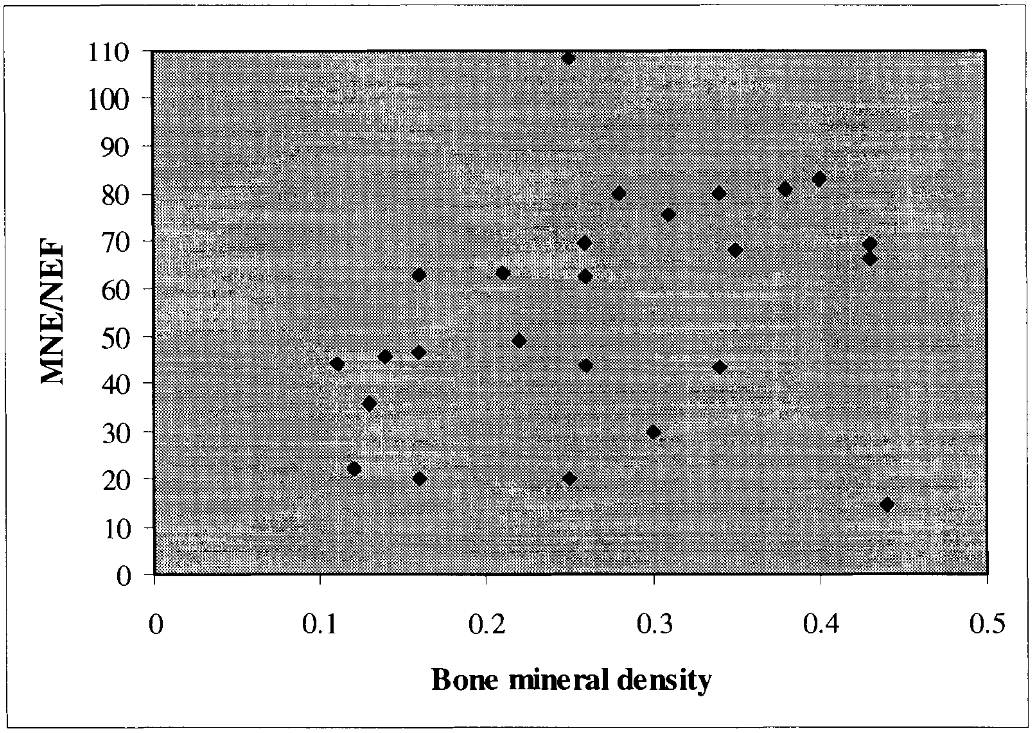

Figure 28. Scattergram plot of bone mineral density (g/cm3; after Lyman 1994:246-247) *vs.* element frequency (expressed as MNE/NEF). Pearson r = 0.33; r^2=0.10; d.f. = 23

Diachronic Analysis

The temporal analysis of body part-distributions within the deer size artiodactyl group is based on comparisons with standardized body part profiles, that is, proportions of different body parts in a living animal. For this purpose, skeletal elements were grouped in the following anatomical regions (*cf.* Stiner 1994:240, 244): (1) head (mandible only); (2) neck (includes axis, atlas, and cervical vertebrae); (3) axial (includes thoracic, lumbar, rib, and innominate); (4) upper front limbs (includes scapula and humerus); (5) lower front limbs (includes radius, ulna and metacarpal); (6) upper hind limbs (femur only); (7) lower hind limbs (includes tibia, astragalus, calcaneus and metatarsals); and (8) feet (phalanges).

Elements with low recovery rates such as horn cores, cranium, sternum, caudal vertebrae, carpals, and tarsals (see Figure 26 above) were excluded from computations. First, standardized MNE-s per anatomical region were obtained by dividing the raw MNE sum per anatomical region (*e.g.*, head, axial, upper front, *etc.*) by NEF-s sum per anatomical region. Second, in order to be able to compare body-part distributions with proportions found in a complete skeleton (*i.e.*, standard), MNE frequencies per anatomical region were also computed (Tables 36 a,b,c).

Overall, the standardized MNE values (sMNE) indicate an increase in body part representations through time. These data are not particularly informative about changes in animal exploitation between time periods because the patterns are related to sample size. Examining the MNE frequencies sheds light on domestic consumption during Mission and later periods because artiodactyls (likely 90% of which were domestic) are represented by all body parts; this suggests that complete carcasses were brought to Middle Village or, more likely, that live animals were brought there and slaughtered. This is similar to the pattern for pre-colonial wild artiodactyls (Potter 1997).

Body-part representations are graphically compared to standard proportions in a living animal in Figure 29 a, b, c. In the sheep-goat distribution, the diachronic body-part proportions are very close to standard. As for deer-pronghorn, during Mission times body-part distributions are fairly similar to standard proportions and to sheep/goat. In Late Historic sample, a different configuration is apparent. Notably, there is an increase in upper front elements (most of which are scapulae). In the combined distribution for all deer-size artiodactyls, including most axial elements (*e.g.*, vertebrae and ribs), an under-representation of axial elements is notable, with lowest values in the sample being from Mission times. This under-representation might be related to the production of spare-rib cuts, favored by the Spanish. The spare-rib cut (or a rack of lamb) is a cultural trait that belongs to the Spanish tradition and was foreign to aboriginal butchering (Lagenwalter and McKee 1985:111). Since the Indians provided labor and service at and for the Missions, they likely did the butchering. The low representation of ribs and vertebrae might be a consequence of the fact that spare-rib cuts could have been transported and/or discarded to areas of the Pueblo inhabited by the Spanish. On the other hand, this variability might be related to the fact that these elements are more susceptible to destruction and have

Table 36a. Sheep/Goat: diachronic body part distribution based on sMNE and % MNE

Body Part	Mission			Post-Revolt			Late Historic			Standard	
	MNE	sMNE	% MNE	MNE	sMNE	% MNE	MNE	sMNE	% MNE	MNE	% MNE
Head	26	13.0	4.22	5	2.5	2.17	28	14.0	2.36	2	4.00
Neck	11	5.5	1.78	17	8.5	7.39	41	20.5	3.46	2	4.00
Axial	9	4.5	1.46	6	3.0	2.60	46	23.0	3.89	2	4.00
Upper Front	52	13.0	8.44	20	5.0	8.69	123	30.8	10.40	4	8.00
Lower Front	66	11.0	10.71	37	6.2	16.08	180	30.0	15.22	6	12.00
Upper Hind	17	8.5	2.75	8	4.0	3.47	37	18.5	3.13	2	4.00
Lower Hind	103	12.9	16.72	48	6.0	20.86	251	31.4	21.23	8	16.00
Foot	332	13.8	53.89	89	3.7	38.69	476	19.8	40.27	24	48.00
Total MNE	616		100	230		100	1182			50	
Total NISP	829			319			1598				

Table 36b. Deer/Pronghorn: diachronic body part distribution based on sMNE and % MNE

Body Part	Mission			Late Historic			Standard	
	MNE	sMNE	% MNE	MNE	sMNE	% MNE	MNE	% MNE
Head	2	1.0	3.17	2	1.0	1.22	2	4.00
Neck	2	1.0	3.17	3	1.5	1.84	2	4.00
Axial	3	1.5	4.76	3	1.5	1.84	2	4.00
Upper Front	8	2.0	12.69	24	6.0	14.72	4	8.00
Lower Front	10	1.6	15.87	17	2.8	10.42	6	12.00
Upper Hind	2	1.0	3.17	3	1.5	1.84	2	4.00
Lower Hind	7	0.9	11.11	33	4.1	20.24	8	16.00
Foot	29	1.2	46.03	78	3.3	47.85	24	48.00
Total MNE	63		100	163		100	50	
Total NISP	101			236				

Table 36c. All deer-size artiodactyls: diachronic body part distribution based on sMNE and % MNE

Body Part	Mission			Post-Revolt			Late Historic			Standard	
	MNE	sMNE	% MNE	MNE	sMNE	% MNE	MNE	sMNE	% MNE	MNE	% MNE
Head	28	14.0	2.92	5	1.1	1.09	31	15.5	1.36	2	1.98
Neck	42	6.0	4.39	34	5.3	7.45	125	17.9	5.52	7	6.93
Axial	189	3.9	19.76	119	2.5	26.09	665	13.8	29.38	48	47.52
Upper Front	72	18.0	7.53	26	6.5	5.70	204	51.0	9.01	4	3.96
Lower Front	94	15.7	9.83	50	8.3	10.96	268	44.7	11.84	6	5.94
Upper Hind	32	16.0	3.34	15	7.5	3.28	92	46.0	4.06	2	1.98
Lower Hind	126	15.8	13.17	103	12.9	22.58	316	39.5	13.96	8	7.92
Foot	373	15.5	39.01	104	4.3	22.80	562	23.4	24.83	24	23.76
Total MNE	956		100	456		100	2263			101	
Total NISP	1074			519			2416				

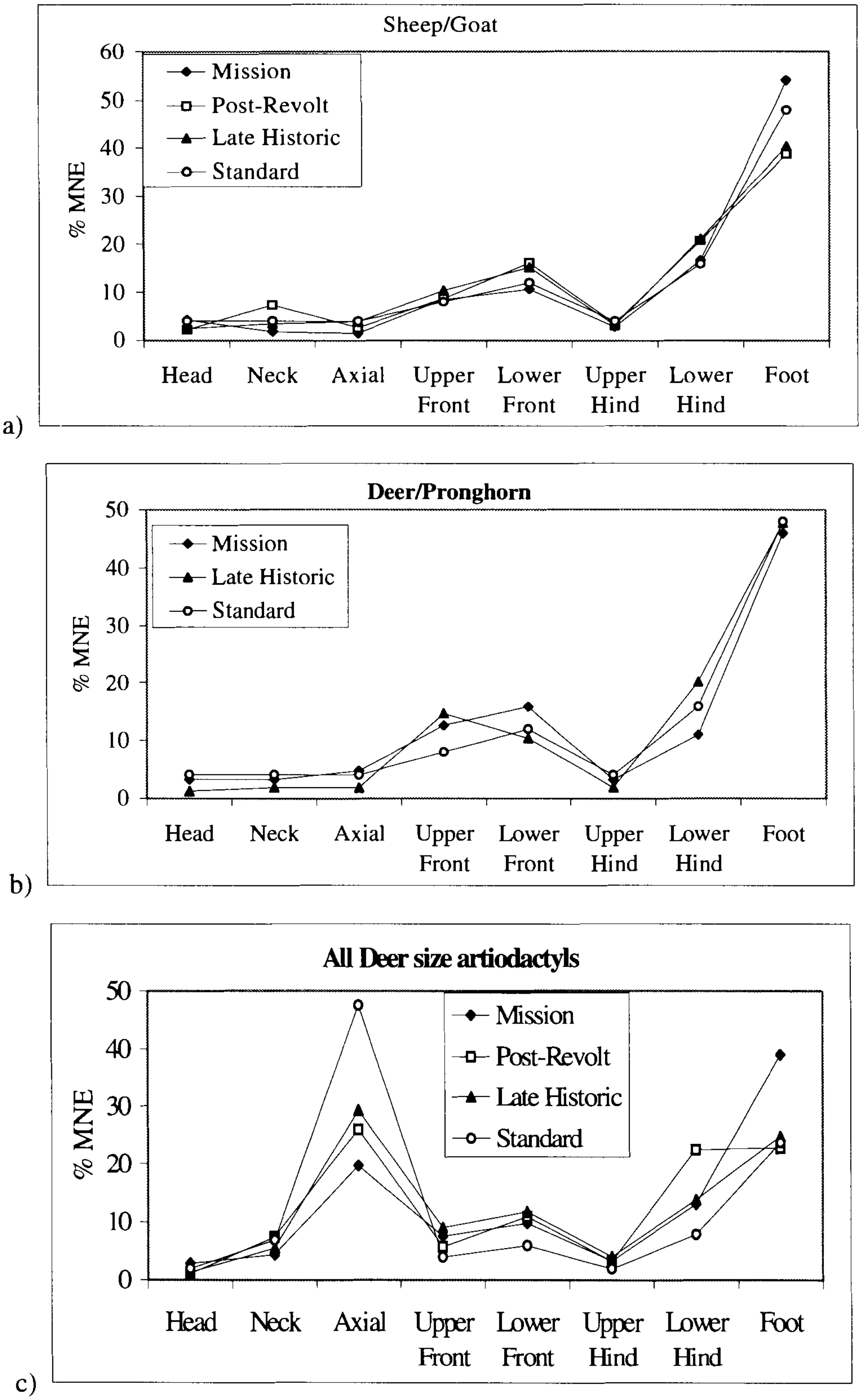

Figure 29. Diachronic body-part distributions compared to standard: a) sheep/goat; b) deer/pronghorn; c) all deer size artiodactyls

lower recovery rates (see the low recovery rates for thoracic vertebrae and ribs in Table 35 c and Figure 26 above). Based on the currently available information, concluding that this pattern implies an ethnic cultural trait cannot be supported. Examinations of faunal assemblages from other areas of the site, particularly of areas known to have been inhabited by the Spanish are needed. Figure 30 a, b illustrate a comparative body-part chronological distribution for sheep/goat *versus* deer-pronghorn, with both groups displaying similar body-part representations during the Mission Period.

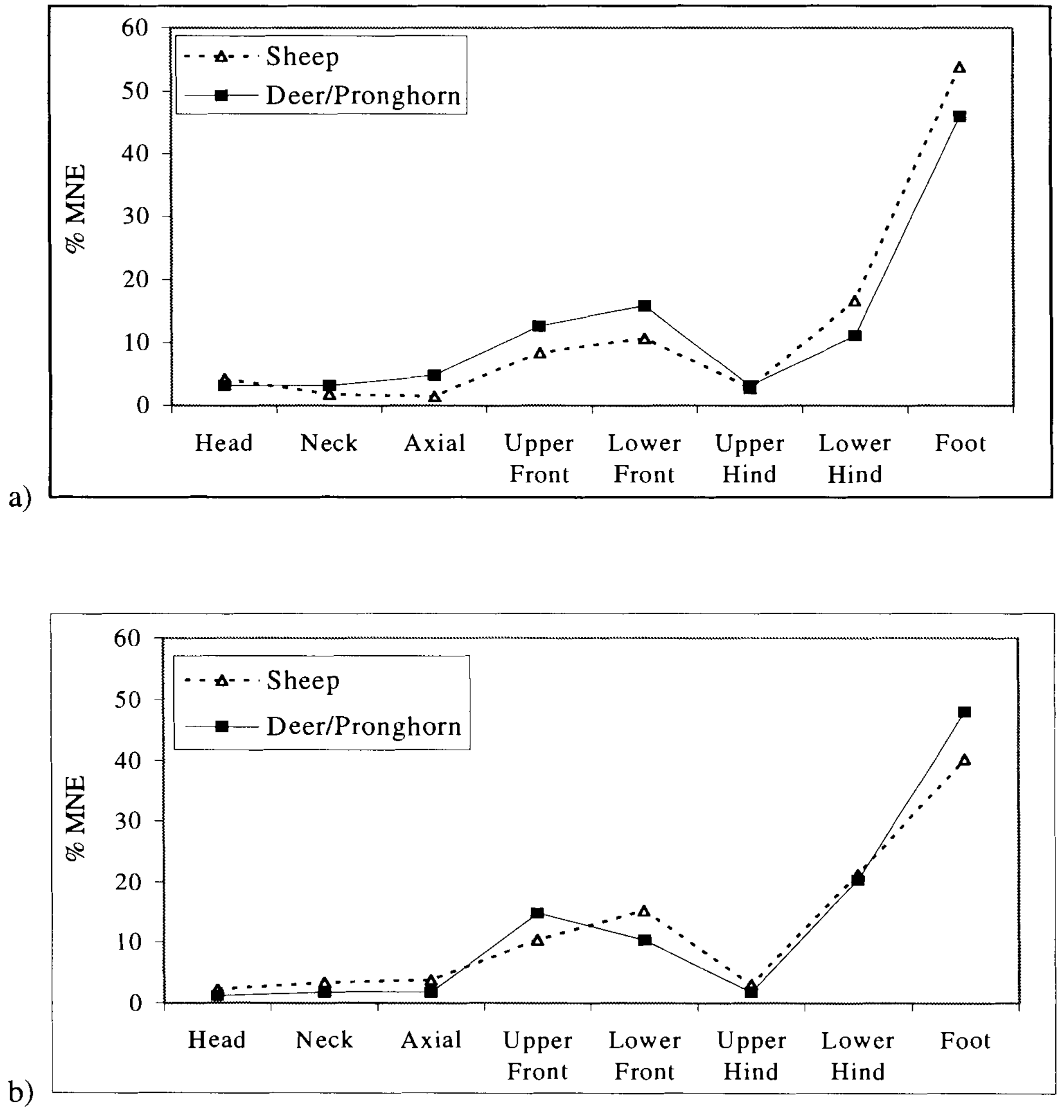

Figure 30. Comparative body-part distributions of sheep/goat *vs.* deer-pronghorn; (a) Mission and (b) Late Historic

During Late Historic times, the allocation of sheep-goat body-parts is fairly similar to Mission. The deer-pronghorn distribution, on the other hand, indicates a shift towards the increase in upper front elements (most of which are scapulae), accompanied by a decrease in lower front elements. The over-representation of deer-pronghorn scapulae in the Late Historic sample is an extremely provocative pattern. This coincides with the increase in deer-pronghorn exploitation observed for Late Historic times (see Figure 13 in Chapter 4). As previously suggested, intensification of wild deer-size artiodactyl hunting in late historic times might be a consequence of increased ceremonialism. Furthermore, ethnographic sources note utilization of deer-pronghorn scapulae as rattles during ceremonies at Zuni (Cushing 1920; Stevenson 1904). A chi-squared analysis was employed to test if the difference between sheep/goat and deer/pronghorn scapula representation relative to all other elements is significant. Results are detailed in Table 37 a and b. The chi-squared test indicates that deer-pronghorn scapulae are over-abundant in the Late Historic sample (note highlighted chi-squared value in Table 37 b), while those of sheep/goat appear in less than expected numbers. Overall, chi-squared results suggest that the increase in deer-pronghorn scapulae in Late Historic times is significant.

Table 37a. Two-by-two table of scapula representation *vs.* all other elements; expected values are shown in parentheses

MNE	Sheep/Goat	Deer/Pronghorn	Totals
Scapula	57 (65)	17 (9)	74
All other elements	1125 (1117)	146 (154)	1271
Totals	1182	163	1345

Table 37b. Calculation table for obtaining chi-squared value from data in Table 37a

	O	E	O-E	$(O-E)^2$	χ^2
Scapula Sheep/Goat	**57**	**65.03**	**8.03**	**64.48**	**0.99**
Scapula Deer/Pronghorn	**17**	**8.97**	**8.03**	**64.48**	**7.19**
Total all other MNE Sheep/Goat	1125	1116.97	8.03	64.48	0.58
Total all other MNE Deer/Pronghorn	146	154.03	8.03	64.48	0.41
X^2 = 8.66; df = 1; P=0.003					

Along with the increase in hunting in Late Historic times, this pattern might illustrate the nature of the syncretic and selective practices that operated at Zuni Pueblo as an expression of the perpetuation of Zuni identity.

Butchery

This section examines patterns of carcass apportionment in the Middle Village area of Zuni Pueblo. The analysis focuses on reconstructions of traditional *versus* Spanish butchery practices. Humans process carcasses for a variety of reasons including extraction of resources such as hide, hair, sinew, bone, horn and antler, marrow and grease, blood and viscera, fat, meat and brains. The conceptual analogical framework used to interpret the way humans process carcasses is based on ethnoarchaeological research. Domingo-Rodriguez points out (2003:385) that researchers select diverse variables in their actualistic studies, which creates a problem because the analytical categories chosen are not closely comparable.

Specific cut marks can be associated with different butchery activities such as skinning, evisceration, carcass dismemberment and apportionment, marrow extraction (Binford 1981; Landon 1996; Lyman 1994). The butchery process usually consists of three stages: (1) primary butchery involving the initial slaughter, carcass dressing, and evisceration; (2) secondary butchery involving the ulterior division of the carcass into major portions; and (3) tertiary butchery or the final apportionment of the carcass into smaller portions for consumption (Lyman 1978:5, 1994:300; Binford 1981; Landon 1996:59). Binford (1981:106-147) systematically describes types of cut marks expected to derive from different stages of killing and processing.

The analysis of butchery marks in historical faunal assemblages from North America has received limited attention (*e.g.*, Crader 1990; Davidson 1982; Landon 1996, 1997; Lyman 1977; Reitz and Scarry 1985; Schultz and Gust 1983). Most of this work describes 19th and 20th -centuries butchery practices. Little work has been done with earlier historic faunal assemblages and with Spanish ones in particular (*e.g.*, Lagenwalter and McKee 1985; Reitz and Scarry 1985).

Criteria generally used to qualify marks on bone as butchery marks are morphology, redundancy (*i.e.,* a mark occurs repetitively on particular areas of a specific element), and purposiveness (*i.e.,* a mark has a potential anatomical purpose for its occurrence in that particular area of the body) (Guilday *et al.* 1962:63; Landon 1996; Lyman 1987:260-270, 1994). As Landon (1996:59) points out, the purposiveness criteria is problematic because “it implies that the researcher is able to define what type of mark has a purpose.” Binford (1981) shares the same opinion and emphasizes other taphonomic agents that can produce purposeful marks.

The first step in the analysis and interpretation of the butchery process at Zuni was to distinguish the types of butchery marks left on bones. This was completed by the use of pre-determined categories based on morphological distinctions or mark morphology criteria (*cf.* Crader 1990; Landon 1996; Reitz and Scarry 1985, 1999). The categories of cut marks identified are:

1) scrape line - a large number of shallow parallel marks that minimally impact the bone surface, generally produced by a knife;
2) cut - a straight, narrow incised mark on the surface of the bone, deeper than a scrape, produced by a knife;
3) chop or hack- a mark through which a wedge of bone was removed; this category also includes shear marks or straight edges produced when the bone has been chopped through; chop and shear marks are produced when using axes and cleavers;
4) saw – straight, smooth marks with finer (electric saw) or coarser (hand-saw) serrations, produced by a metal-toothed tool (Landon 1996:59)

Fine scrape lines were mainly present on scapular blades and occasionally on the horizontal mandibular ramus and long bone shafts. These marks run either parallel or perpendicular to the main axis of the bone and usually result from defleshing. Fine cut marks produced by knives were characteristic to most elements displaying butchery marks, from limb epiphyses and shafts, to cranial and mandibular fragments, to axial elements. These marks are mainly the product of secondary and tertiary apportionment of carcasses. Chops or hacks mainly congregate around limb joints and shafts. Infrequent saw marks were transversely applied to long bone shafts, as well as to vertebrae and ribs, suggesting a separation of the shaft from the ends of the bone or, in the case of vertebrae, a longitudinal splitting of the vertebral column.

Stone tool technology was common at Zuni before the arrival of the Spanish. Metal tools were available but scarce in New Mexico in the years after Coronado's expedition in 1540, but became largely available after the establishment of the Spanish colony in Santa Fe, in 1598. The Franciscan friars transported metal tools such as axes, adzes, hoes, saws, nails, and raw iron (Howell 2003:5; Riley 1999:119). Given the relative isolation of Zuni Pueblo, it is assumed that access to metal tools was probably limited in the first years of Spanish colonialism. Sources report that metal objects were irregularly delivered to the Spanish colony in New Mexico (Riley 1999). A 1639 report reveals that no iron had been shipped to colonists in New Mexico for 11 years (Riley 1999:148).

Recent assessment of flaked stone tool use at Zuni Pueblo suggests that chipped stone manufacture progressively declines through time, with a concomitant replacement with metal tools (Howell 2003b). For example, obsidian percentages decrease to about 5% by Late Historic times (Howell 2003b:2). Only a limited number of ground stone axe fragments were recovered during recent excavations in Middle Village area. Tree-ring data indicate that metal axes were frequently used at Zuni by AD 1690s (Dean 2003). Metal objects are present in deposits dated to Mission times and their frequency increases substantially in the decades to follow. Edge angle examinations also support the view that stone cutting tools were progressively replaced by metal ones. Stone tools continued to be used, but for scraping tasks (Howell 2003b:13).

Some cut marks were examined microscopically in order to avoid confusion with stone tool marks. Binford (1981:105) describes the difference between stone and metal tools as follows:

> Most of the cut marks made on bones with metal tools are almost hairline in size. They often appear to have been cut into the bone from the side, or obliquely, leaving an overlapping small "shelf" of bone that remains in place. For this reason cut marks produced by metal knives are very hard to see when one looks directly down on the bone...In addition to having this diminutive "sliced" look, the marks are generally long, resulting from cuts running across tissue for considerable distances. Cutting with stone tools requires a much less continuous action, more of a series of short, parallel strokes. Also, most stone tools, particularly ones that are retouched, do not have straight or single-

plane cutting edges. Marks from stone tools tend to be short, occurring in groups of parallel marks, and to have a more open cross section. They also have a more ragged appearance when viewed from the top.

Recent microscopic analyses, using a light optical microscope and a Scanning Electron Microscope, of stone and metal tool profiles demonstrate that metal tools produce striations of more uniform depth and spacing and a cleaner and more even slicing cut than stone tools. Stone tools, on the other hand, generally produce shallow grooves with less even sides and leave striations on only one side of the slicing cut (Greenfield 2004:246).

Few bone fragments (less than 15) dated to Late Prehistoric and Contact times in the Zuni assemblage displayed cut marks produced by a metal knife. This is probably a consequence of a depositional history where movement of sediments affected cultural material by causing an admixture of historic with prehistoric remains.

Quantification of Butchering Marks

A commonly-used method in the analysis of butchery techniques is to calculate frequencies of bones displaying cut marks (*e.g.*, Binford 1986:446, 1988:127; Bunn and Kroll 1986:432; Lyman 1994). Shipman (1986, 1988) was amongst the first to argue that cut mark frequencies can provide information on the degree of systematization (*i.e.* standardization) of the butchery technique. As Lyman (1994) points out, in examining frequencies of butchered bones, one should be aware that only a proportion of the elements butchered display butchery marks. In addition, weathering, carnivore and rodent scavenging along with breakage can obliterate butchery marks (Behrensmeyer 1978; Domingo-Rodriguez 2003; Grayson 1989; Maltby 1985). On the other hand, although experiments have shown that spiral fractures are commonly the result of butchery activities, these fractures are not usually included in count frequencies because they can also be a product of natural agents (Binford 1981; Lyman 1984).

Lupo & O'Connell (2002) argue that studies of cut marks have limited value because of a lack of consensus between researchers in what concerns identification, standardization, and reporting cutmarks and cutmark frequencies. The ways in which results can be affected by inconsistencies in identification and quantification have been amply discussed elsewhere (see Blumenschine *et al.* 1996; Capaldo 1997; Domingo-Rodriguez 1999, 2003; Lyman, 1994).

Butchery in the Middle Village Assemblage

For each butchered bone identified, information on anatomic location per element part (*e.g.*, proximal, distal, occipital, ilium, *etc.*), surface on specific element part (*e.g.*, lateral, medial, caudal, cranial, posterior, anterior, *etc.*), mark type (cut, scrape, chop/hack, and saw), orientation (transverse, longitudinal, oblique), tool used (knife, cleaver, ax, or saw), and number of marks at each location were recorded. In order to assess sources of diachronic inter-assemblage variation within deer-size artiodactyl group, cutmark distribution by element and body part were compared. Appendix D presents a diachronic distribution of cut mark frequencies on different element parts by deer-size artiodactyl group. Because discrete temporal analyses led to the conclusion that both wild and domestic deer-size artiodactyls were similarly butchered, cumulative patterns will be presented.

With increased standardization and centralization in the butchery technique, cutmarks can be expected to occur in reduced proportions at articular joints (Landon 1997; Zeder 1991). Limb specimens were grouped in categories including major limb joints; the results are presented in Table 38. (*cf.* Lyman 1994). The analytical categories used are as follows: shoulder, elbow, wrist, hip, knee, and ankle. The shoulder consists of the scapula and proximal humerus. The elbow includes the distal humerus, proximal radius, and proximal ulna. The wrist includes the distal radius, distal ulna, and proximal metacarpals. Carpals were excluded from this category because they bear inconclusive numbers of marks. The hip includes the proximal femur and acetabulum. The knee includes the distal femur and proximal tibia. The ankle includes distal tibia, tarsals, and proximal metatarsus.

Generally, the analysis indicates a decrease in cut mark frequencies at the joints through time. This might be a consequence of boiling. Analyses of ceramics and cuisine in the Middle Village indicate that large metal pots were used for stew preparation during ceremonies in the 20th century (Mills *et al.* 2003). Boiling can reduce cut marks resulting from consumption or tertiary meat removal from the bones. Cut marks frequency distributions on meaty limb shafts are inconclusive and cannot be satisfactorily interpreted in light of the sample currently available.

Table 38. Frequencies of cut-marked specimens at joint and meaty limb shaft locations

Anatomical category	Mission			Post Revolt			Late Historic		
	NISP	N cut	% cut	NISP	N cut	% cut	NISP	N cut	% cut
Shoulder	84	6	7.14	17	1	5.88	148	7	4.72
Elbow	66	12	18.36	44	6	13.63	271	23	8.48
Wrist	69	8	11.59	22	1	4.54	174	13	7.47
Hip	44	4	9.09	25	1	4.00	152	2	1.31
Knee	34	9	26.47	19	1	5.26	164	11	6.70
Ankle	142	27	19.01	83	7	8.43	400	32	8.00
Shaft humerus	5	2	40.00	4	1	25.00	10	2	20.00
Shaft radio-ulna	12	0	0.00	6	4	66.67	40	8	20.00
Shaft femur	8	0	0.00	4	0	0.00	15	8	53.33
Shaft tibia	9	2	22.22	2	0	0.00	19	5	26.31
Totals	473	70		226	22		1393	111	

Diachronic differences in carcass apportionment were further examined by looking at cut-mark frequencies of meaty *versus* non-meaty limbs. Meaty limb bones include the humerus, radius-ulna, femur, and tibia. Metapodials are the non-meaty limb bones. The analysis is presented in Table 39. A decrease in the frequency of cut marks for the scapula and meaty limb elements through time can be noted. This might be the result of the fact that whole bones were prepared in stews during Late Historic times.

Table 39. Frequency of butchered meaty *vs.* non-meaty limbs through time

Anatomical category	Mission			Post Revolt			Late Historic		
	NISP	N cut	% cut	NISP	N cut	% cut	NISP	N cut	% cut
Scapula	60	19	31.66	11	3	27.27	109	19	17.43
Meaty limbs	211	35	16.58	124	13	10.48	854	60	7.02
Metapodials	195	20	10.25	142	6	14.28	178	20	11.23

Butchery by body part

A. Head and Axial

Skull

Marks on the skull are rare, hence reconstructing the butchery pattern is difficult. As discussed in the body-part section of this chapter, this is the result of a high degree of fragmentation of this body part in the assemblage. The ventral surface of some of the occipital condyles display transverse knife or axe marks, which are the result of decapitation (Binford 1981:104). Analogous marks were found on the atlas. In some instances, the head was removed by severing the articulation between the atlas and axis. A series of transverse cutmarks and longitudinal scrapes and cutmarks on parietals and frontals, indicate that skulls were opened and the brain extracted for consumption. Ethnographic sources indicate that heads were baked in outdoor ovens at Zuni and that the brain, tongue, and other pieces of meat available on the skull were eaten (Cushing 1920; Ferguson 1978; Olsen 1982; Stevenson 1904). The same sources suggest that stewing lamb was a common practice in late historic times. Boiling and probably baking the head before cutting the meat off would soften the meat, which in turn would result in reduced numbers of butchery marks on bones (Landon 1996:68).

Horns and antlers were removed by transversal chops or cuts at the base of the horn core. Cut marks at the base of the horn core are usually associated with cutting the skin around the horn core as well as extracting it (Albarella 2003; Binford 1981). Analogous cut marks suggesting skinning were found on the frontal bone, encircling the base of the horncores.

Mandible

Mandibles display cut and scrape marks on both mandibular rami. Cut and scrape marks across the upper part of the ascending ramus, on both lateral and lingual sides, suggest disarticulation of the mandible from the cranium. Oblique marks on the posterior margin of ascending ramus, right below the coronoid and articular processes usually result from the removal of the jaw (Landon 1996). In some instances, the horizontal ramus displayed clusters of cut and scrape marks that are associated with the extraction of the tongue. These clusters mostly concentrate on the anterior part of the mandible, but sometimes occur on the posterior part as well. Few specimens exhibit vertical chops of the anterior portion of the horizontal ramus, just below the diastema. These cuts were presumably made to extract the meat from the jowl or the marrow inside the mandible (Landon 1996).

Vertebral column

Cut marks on the atlas reflect two types of butchery patterns: division of the head from the vertebral column and apportionment of the spine. Transverse or oblique cut marks were found on both dorsal and ventral sides of the atlas and axis. Numerous butchery marks run across both caudal and cranial sides. Longitudinal marks running antero-posteriorly were not observed, suggesting that the carcass was not divided into halves along the vertebral column. However, oblique cutmarks are common. Marks on the posterior ventral face of the atlas and the ventral surface of the axis are commonly associated with decapitation (Binford 1981:107).

Similarly, the butchery pattern on the rest of the vertebral column suggests the way in which carcasses were divided and apportioned. A longitudinal division of the carcass into halves is not evident in the assemblage until Late Historic times. Transverse cuts or chops on the centrum of cervical, thoracic, and lumbar vertebrae are common indicators of carcass apportionment into smaller portions. According to Ferguson (1978), the Zuni used to boil sections of meat containing vertebrae in stews. Cervical vertebrae exhibit transverse or oblique cutmarks on both ventral and dorsal sides. The marks on the ventral side suggest that the animal was killed by slitting its throat. Thoracic vertebrae display marks that result from both apportionment and separation from the ribs. Chops or cuts on the transverse processes were inflicted when separating the thoracic vertebrae from the ribs. These marks are paralleled by similar marks on the dorsal ends of the ribs. The neural spines were also hacked or cut off. Cut and scrape marks, usually on the vertebral spines, are caused when meat is removed from the bone. Lumbar vertebrae have transverse marks on their centrum, as a result of carcass division into smaller units. In late historic times, the centrum of lumbar and thoracic vertebrae was split longitudinally with a sharp cleaver, or saw suggesting the adoption of the medial division of the carcass (*i.e.* the column was cleaved through the vertebral bodies and split in two symmetrical halves). One reason why this technique is not widespread in the assemblage from Middle Village is due to limited access to more powerful tools (*i.e.,* saws) at Zuni Pueblo (Olsen 1982). Transverse cut marks are often found on the sacrum as well.

The ribs were divided into two or three sections by cuts or chops that run roughly parallel to the vertebral column. They were detached from the thoracic vertebrae by cutting through the head or neck and by using either knives, cleavers, or saws. Saw use is characteristic, although infrequent, in later times. Transverse cuts also occurred on rib shafts as they were sectioned for broiling. Some ribs displayed scrape marks on the shaft, probably inflicted during evisceration. Generally, rib and thoracic vertebrae sectioning suggest a paramedial cut of the spine, which is a butchery technique characteristic in early medieval times in Europe (O'Connor 2000), but also at prehistoric sites in New Mexico (Lang and Harris 1984).

B. Limbs

Limbs were separated near joints. This was mainly performed with knives and dismemberment took place from different directions. Some shafts display scars related to marrow extraction, but cut marks are rarely present at the point of impact. Even though extracting marrow from long bones through a longitudinal splitting of the bones is easier, these types of marks are infrequent in the collection. Most of the cut marks on epiphyses suggest that the bone was prepared with the meat on.

Forelimb

The scapulae display two types of cut marks. Most frequent are longitudinal scrapes on both lateral and medial sides of the blade and near borders inflicted to separate the shoulder muscles. Infrequent transverse or oblique knife marks on both sides of the neck and around the glenoid cavity, were caused during secondary butchery when the scapula was dismembered from the humerus. According to Binford (1981:122), large numbers of marks around the scapular glenoid cavity are expected to occur during processing for consumption. Generally, butchery marks suggest that scapulae were extracted intact from the shoulder. Chopping through collum of the scapulae is uncommon in the assemblage. As Binford points out (1981:122), the scapulo-humeral articulation can be disjointed easily by "two simple cuts and a little leverage."

Although proximal humeri have low recovery rates in the collection, some specimens display cut marks. Transverse knife marks, from the disarticulation of the forelimb from the shoulder, were observed on the humeral head and the greater trochanter. These marks are similarly characteristic to secondary butchery (Binford

1981:121). Transverse cuts on the posterior surface of the proximal end of the shaft, that were probably inflicted when the large muscles attached to this area were severed, were also recorded. Two types of cut marks were observed on the distal end of the humerus, namely numerous cut marks on the lateral and medial surfaces of its distal epiphysis and above the humeral condyle, on both anterior and posterior surfaces of the diaphysis. These types of marks are related to the disarticulation of the humerus from the radio-ulna at the elbow. The diaphyses do not show scrapes and cut marks resulting from meat removal for consumption, suggesting that the bones were probably prepared with the meat on. Although impact scars from fracturing the shaft were observed, seldom were cut marks visible.

Marks on the proximal ends of the radius and ulna parallel those found on the distal humeral end. Transverse cuts occur on the anterior surface of the proximal end of the radius and along the diaphysis. Most proximal ulnae display oblique cut marks on the sides of the olecranon. These diagonal cuts, which run from the lateral side of the humerus and impact the olecranon on the same side, are inflicted when the humerus is dislocated from the radio-cubitus. In a few instances in Late Historic material, the proximal radio-ulnar shafts were sawn through.

The wrist was disarticulated by cutting through the distal end of the radius or the proximal end of the metacarpus. Cut marks on carpals are infrequent, but these elements are scarce in the assemblage and therefore, inconclusive. Some cut marks occur on the distal ends of the radio-ulnar shaft, just above the articular surface.

Hindlimb

Pelvises display butchery marks on a variety of locations. Transverse cut marks occur on the ventral side of the pelvis, just anterior or posterior of the acetabulum. According to Binford (1981:114) these marks are usually inflicted during primary butchery, while separating the hindlimb from the vertebral column. The ilium shows longitudinal scrapes and cut marks on its medial side, which presumably occur when the sacrum is disarticulated from the pelvis (Binford 1981:115; Landon 1996:85). These marks are paralleled by similar marks on the lateral margins of the sacrum. Pelvis partitioning was generally made by applying transverse chops through the neck of the ilium. Subdivisions of the pelvis through acetabulum, a pattern generally expected for medium-size artiodactyls, were not observed (Landon 1996). Most cut marks on pelvic parts are associated with secondary or tertiary butchering (*i.e.,* processing for either storage or consumption). Transverse cut marks that may result when the femur is cut free from the hip socket occur around the acetabulum and on the ischium (Binford 1981:113). Butchery evidence poorly substantiates a subdivision of the pelvis in two halves. Longitudinal sawing and chops of symphyses are fairly rare. Only one symphysis was sawn through in Late Historic times.

The femur bears transverse or oblique cut marks on both anterior and posterior surfaces of the femoral head and greater trochanter. These marks are usually inflicted when a knife is inserted to disunite the connective tissue between the meat on the upper leg and muscle attachments in the pelvic area (Binford 1981:116, 117).

The separation at the knee joint was made by either cutting or chopping through the femoral-tibial articulation, by which the distal femur and proximal tibia were disentangled. This operation left transverse cut or chop marks on the posterior surface of the femoral condyles as well as across the posterior side of the diaphysis, right above the condyles. Fine cut marks also occurred across the trochlea, on its anterior surface, when the patella was removed. Dislocation marks on the distal end of the femur are paralleled by analogue marks on the proximal end of the tibia. Ethnoarchaeological examples show that the femoral-tibial articulation is not usually disjointed during primary butchery and remains attached prior to meat distribution or preparation for consumption (Binford 1981:116). Transverse cut marks occur on the femoral and tibial shafts. In the case of the femur, these marks typically result from severing the large femoral muscles from bone. They may also be inflicted when the bone is partitioned for marrow extraction. Tibia displays numerous cut marks on the shaft. This may be the result of a low amount of meat on this bone in comparison to the femur. Some diaphyses show longitudinal scrapes from skinning. Despite the large number of tibia shaft fragments, infrequent cut marks suggest that this bone was butchered into smaller portions.

C. Metapodials and phalanges

Both metacarpals and metatarsals display cut marks on proximal ends. These marks result during their disarticulation from the carpals and tarsals. In a few instances, metapodials were cut or chopped through the center of the shaft for marrow extraction. Cut marks on phalanges are extremely rare. Today, metapodials and phalanges are generally discarded at sheep camps or at places where the slaughtering takes place (Ferguson 1978). In the recent past, feet were either singed or roasted and the hoofs boiled or roasted (Stevenson 1904).

Generalized Butchery Patterns

In this section, general Zuni butchery practices are compared to examples of traditional, Spanish, and Anglo-American patterns as described in ethnographic sources, ethnoarchaeological and other zooarchaeological research.

Traditional Pueblo Practices

An example of processing wild artiodactyls is described for the prehistoric pueblo of Arroyo Hondo, New Mexico (Lang and Harris 1984). The analysis of butchery marks and body-part representations indicates that large mammals were processed away from the site, with selected parts (particularly high-meat-bearing elements) being brought back to the pueblo. The collection from Arroyo Hondo is characterized by an abundance of scapula, humerus, thoracic, lumbar, and cervical vertebrae, ilium, ischium, femur, tibia, astragalus, calcaneus, metapodials, and phalanges. Skull, mandible, thoracic spines, rib ends, sacra, innominate, radius, and ulna fragments are rare. Crania and mandibles are highly fragmented and were not probably brought back at the site. Major butchery characteristics in the assemblage include:

1) skinning marks on the hooves, knuckles, and ankles;
2) removal of the tongue through an incision placed between the dentaries; extraction of the jowl from the mandibles by cutting through the vertical ramus of the mandible; removal of the inferior border of the mandible to extract the marrow;
3) cuts on the axis vertebra suggesting either the defleshing of the neck or decapitation;
4) antler removal by shattering the antler beam in the area of the brow tine

5) removal of the limbs by cuts across articulator joints (*e.g.*, scapulo-humeral, humero-radio-ulnar, acetabulo-femoral, femuro-tibial, *etc*;
6) paramedial detachment of the rib cage by cutting through the ribs below the articulation of the ribs with the thoracic processes; ventral rib ends were also severed to obtain a breast unit;
7) breakage of bones and of cancellous epiphyses for marrow extraction (Lang and Harris 1984:78-85).

Zuni Butchery Practices

A sheep was butchered at Zuni in 1978 by T.J. Ferguson with the help of Zuni locals, in order to obtain a scientific specimen. Traditional Zuni butchery techniques were at times not followed in order to extract the bones intact. The process is described below:

> The sheep was killed by slitting its throat with a very sharp knife...Once drained the sheep was skinned by placing it on its back with its underside exposed. A small incision was made through the skin in the area of the ribs. This incision was then extended up to the neck, and the head cut off. Incisions were then extended from the center cut to each of the front legs; with the skin being separated from the carcass by pulling on it and slicing the membrane which separates the two...the incision was continued up to the forelimb, and then completely around the foreleg right above the hoof. Generally all four legs are cut off at the joint and discarded; leaving, however, tendons attached in the upper legs that are useful for hanging the sheep up after butchering. In this case, the forelegs were left articulated and just the skin removed from the legs...A long incision was then made down the length of the belly, and the skin began to be pulled back from the carcass by either slicing the membrane or using a fist to push and separate it...a similar process as performed on the front legs was repeated on the back legs. After the sheep was skinned, the internal organs were removed. This was done by making an incision in the belly and extending it up to the rib cage and down to the anus of the sheep. The esophagus was tied in a knot to prevent the contents of the stomach from spilling out, and then pulled through the neck to now exposed cavity containing the organs easier. As this sheep was butchered to provide a whole skeleton for a scientific specimen, the sternum was left intact. The stomach and intestines were pulled out into a clean pan and saved. The heart, lungs, liver and bladder were then removed, and all saved except the bladder which was immediately discarded. Sometimes, if the carcass is to be hung up for awhile, the liver and bladder are left in to dry up before removal. After the organs were removed, the animal was ready for storage or consumption. If it was to have been stored, the carcass would have been hung up in a well ventilated place using the tendons still attached in one of the back legs as a loop to put over a hook...It should be noted that the preparation of the skeleton for a scientific purpose greatly reduced the amount of the sheep which normally would have been consumed...many parts of the sheep were wasted. In particular the head, ribs, and marrow in the long bones were not consumed as they might have been otherwise (Ferguson 1978).

This description is very similar to Arroyo Hondo and to contemporary Navajo sheep butchering described by Binford and Bertram (1977:90-96). Binford and Bertram's data are based on information obtained from Navajo people. The butchery sequence includes the following stages: choosing a big fat sheep (age and reproductive conditions are considered), killing it by cutting the throat, butchering, and hanging. A summary of the patterns of consumption is given below:

> Butchered meat is consumed locally, and the methods described indicate that no breaking of bones is carried out for the express purpose of marrow extraction or the rendering of bone grease. Some breakage occurs, however, in preparation of long bone joints for "soup bones" and in the preparation of ribs for inclusion in soups, as well as skulls in roasting. Aside from the acts of dismemberment, there is nothing in the process of consumption that should reduce the number of identifiable anatomical parts present at a site. Contemporary practices result in some deletions from the site, particularly phalanges, metapodials, and occasionally radio-cubiti which are sent together with the skin to a tanner. In addition, meat distributions to friends and relatives occur from time to time...Disposal occurs locally, and untethered dogs have free access to all the discarded bones. With the exception of possible deletions, differences noted in the presence of anatomical parts on a Navajo site relative to their anatomical frequency should be attributable to differential destruction of parts by dogs (Binford and Bertram 1977:95-96).

However, we need to keep in mind that Navajos value mobility and their practices of consumption and meat distribution might differ to some extent from sedentary people such as the Zuni.

Spanish Butchery Practices

Information on Spanish sheep butchery pattern is limited. Ethnic Spanish attributes, as described for cattle and probably similar for sheep carcass dismemberment and processing are:

1) primary disarticulation at the joints by severing tendons and ligaments;
2) meat deboning with the exception of the production of spare-rib cuts;
3) bone breakage for marrow extraction;
4) use of cleavers, knives, and axes (Lagenwalter and McKee (1985:110-111).

The Spanish are also known to have preferred the 'spare-rib' cut. Therefore, hypothesizing a higher representation of ribs and thoracic vertebrae would be found in Spanish deposits is valid. A paramedial detachment of the rib cage, very similar to traditional aboriginal practices, persisted in Europe in medieval times.

Generally, traditional and Spanish butchery patterns look very similar, with the exception of production of spare rib cuts and the use of metal tools. The introduction of metal tools might have determined change in some aspects of the butchering process such as the specific place, angle, and standardization of cutting. Standardization is usually described by a reduction in the number of cut marks at the joints (Zeder 1991). However, the basic pattern of butchering is not expected to have been significantly different with the replacement of stone tools.

Anglo-American Butchery Practices

Anglo-American butchery practices in the 19th century are particularly characterized by a high degree of standardization and specificity of cuts. Animals are sent to specialized butchers who use saws to produce a variety of discrete cuts of meat through cross-cutting of bones (Lagenwalter and McKee 1985:111; Landon 1996). In the 17th century, the frequency in the use of saws and the proportions of bones cut by saws is reduced compared to 19th century (Landon 1996). Access to saws at Zuni Pueblo was limited in Late Historic times (Olsen 1982) and, consequently, the impact of Anglo-American practices would be minimal, unless the Zuni were increasingly buying meat cuts from the market.

A translation of the general patterns of deer-size artiodactyls carcass apportionment in the Middle Village area is presented in Figure 31 and Table 40. A reduced amount of variation in butchery patterns within the group was observed, suggesting that both wild and domestic artiodactyls were butchered the same way. Previous discussion of butchery marks on individual elements does not demonstrate a significant amount of variation in the way in which different parts of the carcass of wild and domestic artiodactyls were treated.

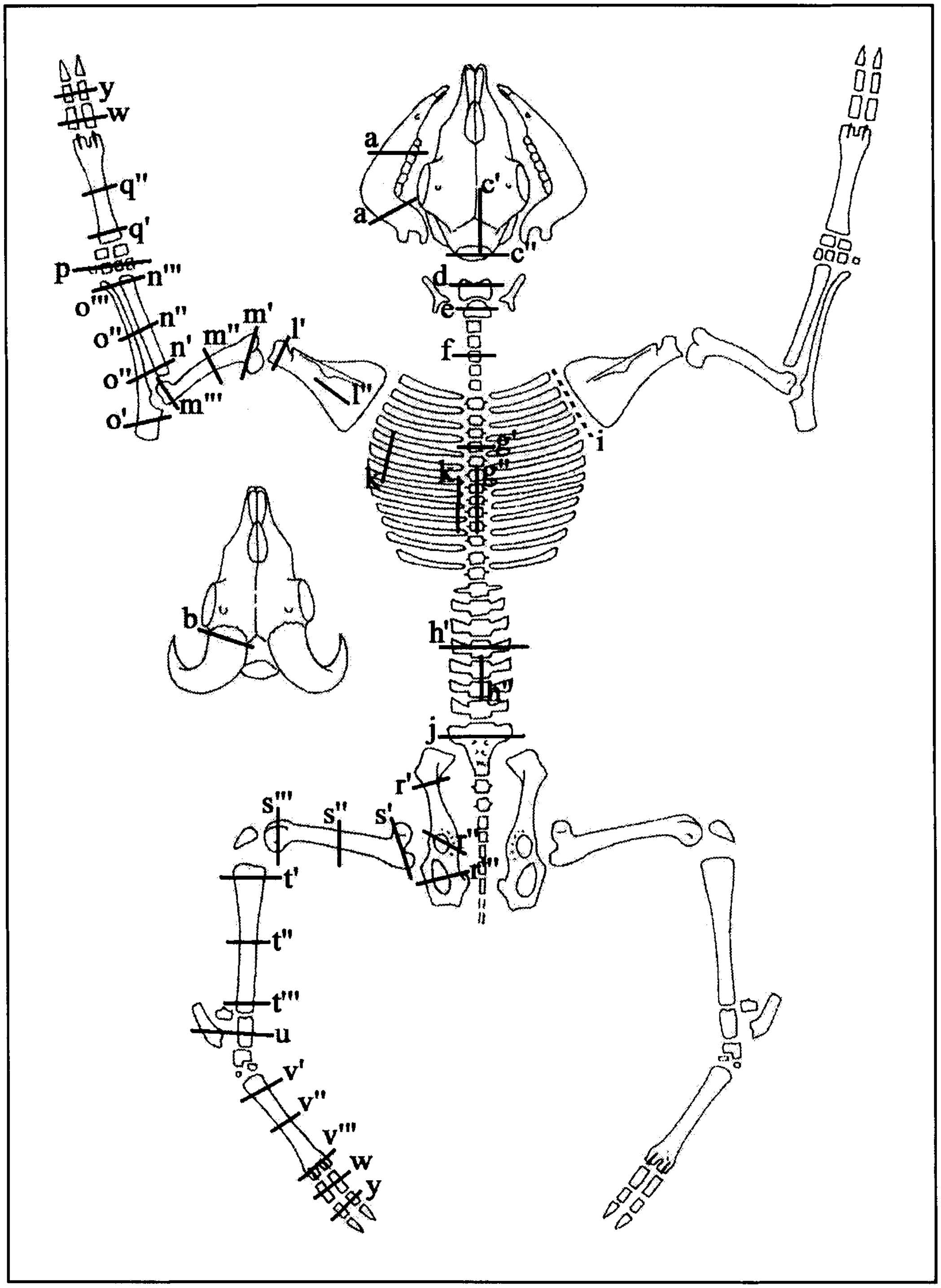

Figure 31. Carcass division for all deer-size Artiodactyls (sheep/goat + deer/pronghorn + indeterminate deer-size artiodactyls) through time; see Table 40 for key.

Table 40. Chronological distribution of butchery marks on deer-size artiodactyl elements and element parts

	Mission							Post-Revolt							Late Historic						
Element	NISP	NBT	% BT	SC	CT	CH	SW	NISP	NBT	% BT	SC	CT	CH	SW	NISP	NBT	% BT	SC	CT	CH	SW
Horn Core/Antler (b)	11	5	45.45	0	0	15	0	7	4	57.14	0	0	15	0	28	12	42.85	0	12	14	0
Skull (c')	14	1	7.14	0	2	0	0	3	0	0.00	0	0	0	0	34	4	11.76	12	7	0	0
Mandible (a)	32	8	25.00	14	17	0	0	6	2	33.33	0	0	0	0	41	3	7.31	20	5	5	0
Neurocranium (c")	2	2	100.00	0	6	2	0	2	0	0.00	0	0	0	0	9	3	33.33	0	14	0	0
Atlas (d)	7	4	57.14	0	7	1	0	8	1	12.50	0	0	0	0	22	5	22.72	0	42	0	0
Axis (e)	6	4	66.67	0	17	0	0	8	3	37.50	0	2	2	0	30	3	10.00	0	2	1	0
Other cervical (f)	30	2	6.67	0	2	1	0	18	2	11.11	0	8	0	0	84	4	4.76	0	22	4	0
Thoracic vertebra (g', g")	48	6	12.50	0	17	5	0	23	4	17.39	0	1	3	0	153	14	9.15	0	23	6	5
Lumbar vertebra (h', h")	41	7	17.07	0	42	14	0	34	1	2.94	0	5	0	0	177	22	12.42	0	39	12	7
Sternum (i)	11	1	9.09	0	0	1	0	2	0	0.00	0	0	0	0	25	3	12.00	0	3	3	0
Sacrum (j)	2	2	100.00	0	12	0	0	1	0	0.00	0	0	0	0	22	5	22.72	0	7	0	0
Caudal	17	0	0.00	0	0	0	0	2	0	0.00	0	0	0	0	10	0	0.00	0	0	0	0
Ribs (k)	139	32	23.02	11	60	4	0	61	14	22.95	0	41	1	2	351	69	19.65	20	152	17	4
Scapula total	60	19	31.66	104	9	0	0	11	3	27.27	4	2	0	0	109	19	17.43	87	26	1	0
Scapula neck (l')	66	5	7.57	0	9	0	0	11	0	0.00	0	2	0	0	91	6	6.59	0	26	1	0
Scapula blade (l")	77	17	22.07	104	0	0	0	11	3	27.27	4	0	0	0	112	15	13.39	87	0	0	0
Humerus	38	6	15.78	0	20	2	0	19	3	15.78	0	7	0	0	171	9	5.26	0	29	0	0
Humerus proximal (m')	18	1	5.55	0	4	0	0	6	1	16.67	0	2	0	0	57	1	1.75	0	9	0	0
Humerus shaft (m")	5	2	40.00	0	0	2	0	4	1	25.00	0	2	0	0	10	2	20.00	0	15	0	0
Humerus distal (m"')	19	4	21.05	0	16	0	0	11	1	9.09	0	3	0	0	95	6	6.31	0	5	0	0
Radius	48	8	16.67	0	21	0	0	30	4	13.33	0	7	0	1	201	22	10.94	0	90	4	2
Radius proximal (n')	23	5	21.70	0	16	0	0	16	1	6.25	0	2	0	0	92	14	15.21	0	48	4	1
Radius shaft (n")	11	0	0.00	0	0	0	0	5	3	60.00	0	5	0	1	35	6	17.14	0	33	0	1
Radius distal (n"')	21	3	14.28	0	5	0	0	14	0	0.00	0	0	0	0	107	4	3.73	0	9	0	0
Ulna	31	5	16.12	14	3	0	0	21	4	19.04	8	1	0	1	108	4	3.70	0	15	2	0
Ulna proximal (o')	24	3	12.50	7	3	0	0	17	4	23.52	3	1	0	0	84	3	3.57	0	10	1	0
Ulna shaft (o")	1	0	0.00	0	0	0	0	1	1	100.00	5	0	0	0	5	2	40.00	0	3	1	0
Ulna distal (o"')	5	2	40.00	7	0	0	0	3	0	0.00	0	0	0	0	21	1	4.76	0	2	0	0

Table 40. Crhonological distribution of butchery marks on deer-size artiodactyl elements and element parts cont'd

	Mission							Post-Revolt							Late Historic						
Element	NISP	NBT	% BT	SC	CT	CH	SW	NISP	NBT	% BT	SC	CT	CH	SW	NISP	NBT	% BT	SC	CT	CH	SW
Carpals (p)	37	0	0.00	0	0	0	0	20	2	10.00	0	3	0	0	47	0	0.00	0	0	0	0
Metacarpus	96	5	5.20	3	17	0	0	19	2	10.52	0	1	2	0	75	11	14.66	0	41	0	0
Metacarpus proximal (q')	48	5	10.41	0	17	0	0	8	1	12.50	0	1	0	0	67	9	13.43	0	38	0	0
Metacarpus shaft (q'')	10	1	10.00	3	0	0	0	8	0	0.00	0	0	2	0	34	2	5.88	0	3	0	0
Metacarpus distal (q''')	46	0	0.00	0	0	0	0	11	1	9.09	0	0	0	0	64	0	0.00	0	0	0	0
Innominate	23	4	17.39	0	20	5	0	15	1	6.67	3	4	0	0	80	15	18.75	0	56	8	1
Ilium (r')	15	2	13.33	0	6	5	0	10	1	10.00	3	0	0	0	60	7	11.66	0	31	4	0
Acetabulum (r'')	14	1	7.14	0	2	0	0	10	1	10.00	0	2	0	0	64	1	1.56	0	4	1	0
Ischium/Pubis (r''')	13	2	15.38	0	12	0	0	9	1	11.11	0	2	0	0	57	11	19.29	0	21	3	1
Femur	49	6	12.24	0	19	0	0	24	0	0.00	0	0	0	0	180	15	8.33	0	46	4	1
Femur proximal (s')	30	3	10.00	0	9	0	0	15	0	0.00	0	0	0	0	88	1	1.13	0	3	0	0
Femur shaft (s'')	8	0	0.00	0	0	0	0	4	0	0.00	0	0	0	0	15	8	53.33	0	19	2	0
Femur distal (s''')	17	3	17.64	0	10	0	0	7	0	0.00	0	0	0	0	85	7	8.23	0	24	2	1
Tibia	45	8	17.77	6	33	0	0	30	1	3.33	0	2	0	0	194	10	5.15	0	46	2	0
Tibia proximal (t')	17	6	35.29	0	26	0	0	12	1	8.33	0	2	0	0	79	4	5.06	0	6	2	0
Tibia shaft (t'')	9	2	22.22	6	5	0	0	2	0	0.00	0	0	0	0	19	5	26.31	0	16	0	0
Tibia distal (t''')	27	1	3.70	0	2	0	0	20	0	0.00	0	0	0	0	128	3	2.34	0	24	0	0
Tarsals (u)	72	17	23.61	0	45	0	0	51	5	9.80	0	12	0	0	216	20	9.25	0	65	1	0
Metatarsal	99	11	11.11	5	25	0	0	23	4	17.39	0	12	0	0	103	9	8.73	3	28	0	0
Metatarsus proximal (v')	43	9	20.93	0	23	0	0	12	2	16.67	0	9	0	0	56	9	16.07	0	24	0	0
Metatarsus shaft (v'')	21	2	9.52	5	2	0	0	2	2	100.00	0	3	0	0	29	1	3.44	3	4	0	0
Metatarsus distal (v''')	55	0	0.00	0	0	0	0	9	0	0.00	0	0	0	0	62	0	0.00	0	0	0	0
Metapodials	48	0	0.00	0	0	0	0	17	0	0.00	0	0	0	0	70	1	1.42	3	0	0	0
1st phalanx (w)	182	2	1.09	0	5	0	0	52	0	0.00	0	0	0	0	271	1	0.36	0	5	0	0
2nd phalanx (y)	120	0	0.00	0	0	0	0	36	0	0.00	0	0	0	0	170	2	1.17	0	5	0	0
3rd phalanx	78	0	0.00	0	0	0	0	21	0	0.00	0	0	0	0	133	0	0.00	0	0	0	0
Totals	**2029**	**244**	**12.56**	**289**	**566**	**57**	**0**	**802**	**85**	**10.60**	**30**	**144**	**25**	**5**	**4730**	**413**	**9.00**	**235**	**1157**	**105**	**24**

In exploring the data in Table 40, a few patterns are apparent. First, the proportion of cut-marked specimens per anatomical category in the sample from Mission times is significantly but weakly correlated with the total NISP per anatomical category (r = 0.46; P=0.000). The same is true for the sample from the Post-Revolt period (r = 0.53; P=0.000). The correlation coefficient is even higher for the Late Historic sample (r = 0.63; P=0.000). These data suggest that the proportions of cut-marked specimens are, in part, a function of sample size. The total NISP per anatomical category from Mission samples is strongly correlated with the NISP per anatomical category from Post-Revolt samples (r = 0.78; P=0.000) and with the NISP per anatomical category being found in the Late Historic samples (r = 0.76; P=0.000). The highest correlation is between the NISP per anatomical category for Post- Revolt and Late Historic (r = 0.93; P=0.000). Second, the proportion of cut-marked specimens per anatomical category from Mission is strongly correlated with the proportion of cut-marked specimens from Post-Revolt (r = 0.79; P=0.000) and from Late Historic (r = 0.85; P=0.000). Similarly, the proportions of cut-marked specimens per anatomical category from the Post-Revolt Period is strongly correlated with the proportion of cut-marked specimens from the Late Historic Period (r = 0.80; P=0.000). These data suggest that perhaps there are no differences between the three periods in the way deer-size artiodactyls were butchered. However, data are inconclusive as they may be a consequence of sample size.

In Zuni traditional butchering, all animal parts and products were exploited (Ferguson 1982). Butchery marks on bones reflect all stages of the butchery process, and also indicate the use of metal tools as early as Mission times. The butchery process began with killing, eviscerating, and possibly hanging the animal. Examples of primary butchery include the marks on the ventral side of the axis (which can be correlated with slitting the throat) and on the calcaneum (which can be correlated with hanging the animal). Skinning is not clearly represented in the assemblage, with the exception of encircling marks around horn-cores and on the anterior portion of the mandible. Skinning marks on metapodials or phalanges were not observed, probably because these elements were either boiled or roasted. Certain aspects of butchery patterns are difficult to interpret due to the fragmentary nature of the remains (*e.g.*, skull).

Secondary butchery is more clearly represented in the assemblage and is exemplified by the numerous cutmarks left on bones when the carcass was divided into specific portions. The vertebral column was apportioned transversally. In the sample from the Late Historic period, some thoracic and lumbar vertebrae displayed a longitudinal split through the centrum, suggesting a dorsal sectioning of the vertebral column (*i.e.*, the carcass was divided in halves across the spine). Overall, the paramedial sectioning of the spine through the dorsal end of the ribs and the processes of thoracic vertebrae persists. Limbs were dismembered at the joints. A finer-scale division of the carcass in smaller portions associated with specialized butchers was not identified in the present data. This correlates well with the scarcity of elements in the assemblage affected by saws.

Aspects of tertiary butchery are evident, but not particularly numerous in the assemblage. Limb bones do not display cut and scrape marks on the bone surface resulting from meat removal. Boiling prior to boning might have reduced the amount of scrape and butchery marks on bones. Direct evidence for marrow processing is minimal, although many diaphyses display spiral fractures. In some instances, correlating specific butchery marks to uses of different parts of the carcass was possible. For example, clusters of marks on the ascending mandibular ramus were associated with cheek consumption. Butchery marks related to consumption reflect eating of the tongue, cheek, meat, and marrow.

One of the most interesting features of the butchery pattern in the present assemblage is the similarity with the faunal data from Waterline (Olsen 1982). Although butchery marks were not tabulated in Olsen's study, the use of saw marks seems to be more frequent when compared to Middle Village area. One explanation for this difference may be that materials studied by Olsen are of much later date than those from the Middle Village area. Another possible explanation might be that in the Middle Village area animals were butchered in a more home-style manner.

Overall, the patterns of butchery observed in the assemblage from the Middle Village can be summarized as follows: 1) paramedial and transverse carcass apportionment; 2) dismembering at the joints; 3) minimal meat deboning; 4) minimal bone breakage; and 5) the use of metal tools, predominantly knives and reduced use of cleavers, axes, and saws. Chronological variation in the manner of butchering wild and domestic artiodactyls is negligible. The patterns from Middle Village incorporate Spanish attributes, but the degree to which Hispanic butchery affected aspects of traditional Zuni butchery is highly speculative. Meat deboning marks might have been reduced through the method of cooking and preparation used (*e.g.*, boiling). Bones were probably broken for marrow extraction, but marks at the point of impact are scarce. The adoption of metal tools by the Zuni is clearly indicated in the assemblage, as early as Mission times. Many butchery patterns of carcass apportionment in Middle Village are also very similar to the patterns described for deer processing at Arroyo Hondo (see Lang and Harris 1984: 81, Figure 11) and for contemporaneous Navajo sheep butchering (Binford 1981; Binford and Bertram 1977). Saw marks and finer-scale apportionment, as imprints of the Anglo-American butchery, are scarce in assemblages dated to later historic periods.

Chapter Summary

Some general comparisons of butchery and body-part representations were attained in the present analysis. Body-part representations suggest that whole deer-size artiodactyls were brought to Middle Village. The presence of a wide range of body parts, including skull and extremity fragments is similar for both wild and domestic artiodactyls. No portions of the carcass are completely absent in the assemblage. Recovery rates are fairly close to the survival percentages expected based on bone density. The under-representation of certain elements (*e.g.* small bones or cancellous element parts) has been attributed to taphonomic factors such as recovery procedures or the impact of scavengers. The over-representation of deer-pronghorn scapulae in Late Historic samples was suggested to be a consequence of cultural selection for this element because of its ceremonial use. This pattern correlates well with the intensification in hunting deer and pronghorn during this period. The over-abundance of phalanges suggests that this portion of the carcass was not removed in earlier phases of the butchery process and instead was discarded in this area of the site. The under-representation of ribs cannot be clearly linked to the Spanish preference for the 'spare-rib cut' but rather to taphonomic processes. Similarly, data do not indicate an exchange of certain carcass parts in the American period.

The butchery and body part information also support the idea that all butchery stages (*i.e.,* primary, secondary, tertiary) took place in this area of the site. Main differences from the Pre-historic period lie in the adoption of metal tools. The frequency of butchery marks seems to decline on meatier portions of the carcass through time. Boiling might have been responsible for this phenomenon. An identification of the butchering process as belonging to the Spanish tradition cannot be ascertained at this time and the extent to which the patterns represent Spanish attributes is questionable. Spanish influence can be more clearly seen in the adoption of new technologies rather than in changes in butchery practices. Steel tools probably produced modifications in some aspects of the butchering process such as the specific place and the angle of cutting, but this is difficult to assess when considering the butchery process as a whole. Similarly, the American influence seems to be minimal in this area of the site. Data do not indicate a change in the pattern of butchery in the late 18th and 19th centuries, with the increased involvement in the American economic system generally characterized by more standardized patterns of carcass division. Some change can be seen in the present study as reflected in the treatment of the carcass apportionment that show new, but infrequent, butchery patterns in the Late Historic period. In addition, a trend toward a finer apportionment of the carcass characteristic to specialized butchers was not obvious in the assemblage. There is no indication of increased specialization and centralization of butchering and related market industries. The butchery patterns in the Middle Village represent household, unspecialized, traditional practices and wild and domestic artiodactyls were similarly apportioned.

CHAPTER 7
CONCLUSIONS

Introduction

This dissertation explores Zuni diet and food habits during the years of the Spanish, Mexican, and American Periods. Specific conclusions about aspects of Zuni life as reflected in animal use can be drawn by comparing the results of the zooarchaeological analysis to the objectives and research questions discussed at the beginning of this study. In Chapter 1, research question and hypotheses were formulated as to how the patterning and attributes of the faunal assemblage can serve in interpreting aspects of Zuni subsistence system after the onset of the Spanish regime. The present study focused on the following research questions:

1. When did European-introduced domesticates begin to play an important role in the Zuni economy, and does this support the documentary evidence concerning the use of domesticates?
2. How did the Zuni make use of the introduced domesticates? Did they adopt European management practices immediately, or was there a transition period? Were domesticates used primarily as a meat source, or were other functions (*i.e.,* secondary products) relevant? Can a transition from a mainly meat economy to a primarily cash economy based on wool be detected?
3. How were animals butchered? Were aspects of traditional Zuni butchery techniques retained along with patterns of European butchery techniques?

In the following sections, these research questions will be reexamined in light of the results of the analysis presented in Chapters 4, 5, and 6. The temporal variability observed in the assemblage will be compared to the initial hypotheses presented in Chapter 1. The results will also be contrasted with studies of material culture from the Middle Village and with faunal data from Spanish colonial sites in other geographic regions.

Three aspects of assemblage variability including temporal taxonomic variability, population structure, and body-part representations and butchery patterns and the results of the analysis are individually discussed below.

Temporal Taxonomic Variability

In Chapter 4, the patterns of temporal taxonomic variability were presented and interpreted. As the analysis indicates, the variability observed between Pre- and Post-Contact sub-assemblages appears to be significant. Overall, a wide range of mammals and wild birds are represented. Wild birds, turkey, and lagomorphs are more common in pre-Contact deposits, a pattern that is consistent with an economy based on hunting small prey and raising turkey. Post-Contact deposits as early as the Mission Period, are characterized by a decrease in lagomorph and turkey procurement as domestic artiodactyls increase. This trend was previously identified by Etnier (1997) and was also documented in historic assemblages from a different area of Zuni Pueblo (Olsen 1982). One hypothesis that pertains to taxonomic variability was drawn from evolutionary ecology. This hypothesis postulated that the introduction of Old World domesticates, species with low search times, will entail an increase in local foraging efficiency which, in turn, will be accompanied by a decrease in the abundance of low-ranked species such as lagomorphs and turkey.

In general, taxonomic frequencies present broad similarities among the three Post-Contact sub-assemblages. Specifically, there is an increase in domestic artiodactyls from Mission times onward. Domestic sheep dominate the Old World component in each of the three diachronic sub-assemblages. Generally, frequency distributions of taxa support the predictions of the prey choice model. One interesting pattern was a persistence and even increase in hunting wild artiodactyls such as deer and pronghorn in the Late Historic Period. This trend cannot be explained as a purely economic decision, which suggests that other factors were probably involved. Wild animals and their products played important roles in Zuni ceremonial activity and this may explain the increase in the number of wild artiodactyl remains in the old, religious core of the pueblo. This explanation is supported by the fact that the procurement of wild, deer-size artiodactyls, was not as intense in one of the outlier villages in the Zuni area (Etnier 1997) or in the other area of Zuni Pueblo (Olsen 1982) from which zooarchaeological data are available. A reduced representation of wild artiodactyls compared to Old World domesticates has also been documented in other historic sites in New Mexico (Veno Sunseri and Gifford-Gonzales 2002). The persistence of aspects related to Zuni traditional lifeways, as reflected in the increase in deer and pronghorn hunting, can be better explained through the syncretic/selective hypothesis presented in Chapter 1. This pattern reflects a retention of practices that reproduce Zuni identity and these are more likely to occur in areas that are closely related to Zuni tradition. Faunal data are supported by the persistence of aboriginal architectural styles in the Middle Village (Howell 2003a) through Late Historic times. Finally, these faunal temporal trends appear to be statistically significant, as demonstrated by the contingency analysis presented in Chapter 4.

The findings regarding the taxonomic representation in this study agree well with the hypothesis presented by Reitz and Scarry (1985) concerning Spanish responses to new environments and also with Reitz's (1999) conclusion about the array of factors that condition the adoption and incorporation of new foodways into local, aboriginal economies. Sheep adapted well in the Zuni region and provided a clear economic advantage over local traditional resources. However, despite the economic benefits brought about by the introduction of domestic livestock, some aspects of Zuni traditional lifeways have persisted. This view is also supported by material culture and architectural data in the Middle Village (Howell 2003a; Mills *et al.* 2003; Webster 2003). For example, the analysis of textiles and weaving tools (Webster 2003:26) indicate that even though the Zuni adopted European textile tools and styles they also continued to use their aboriginal weaving tools and technologies as well as their pre-contact textile styles throughout the Historic Period. Ceramic analyses in the Middle Village area also suggest continuity in many aspects of Zuni cuisine and point out that many enduring features of Zuni foodways had their origins in pre-Hispanic times. They indicate that many of the changes in cooking vessels that were perpetuated throughout the historic era, occurred at Zuni Pueblo before the introduction of European domesticates. These changes are mostly attributed to increased ceremonialism, demographic changes, and labor saving concerns. Similarly, the shifts in ceramics that occurred throughout the Historic era are mostly attributed to local labor demands rather than to Spanish introductions. Cooking vessels were used at Zuni for stews in Late Prehistoric times and they continued to be used throughout Historic times, the only change being the incorporation of new meats (Mills *et al.* 2003:27). Ceramic analyses conclude that despite the considerable amount of change in cooking vessels in post-Hispanic times, many aspects of Zuni cuisine remained the same.

Overall, the Zuni diet probably underwent rapid change during the Mission period, as domestic sheep were adopted and became an important new source of meat. When dealing with faunal assemblages from stratified deposits in continuously occupied sites caution is warranted. In this case there is no clear evidence for a slow, gradual transition to a new diet. Current data do not suggest sheep ownership at Zuni Pueblo as early as Mission times, but if the residents in the old core had sheep in their possession, this might be indicative of a certain degree of autonomy or reciprocity with the Spaniards. Documents dating to 1639 from Santa Fe note that "each religious has from one to two thousand sheep" (Hackett 1937:66-74). If documentary data are accurate, it is then possible that the priests at Zuni owned sheep in the 17th century. It is not clear how the Zuni gained access to European domesticates in Mission times. Was the access to sheep limited to priests or converts exclusively, or were the Zuni provided with sheep as payment for services rendered? It is likely that some form of reciprocity through trade existed and this might explain the presence of sheep in the Middle Village during the Mission Period.

Sheep became important rapidly, and remained so throughout the site history. A rapid adoption of sheep into Zuni diet was influenced by both environmental and cultural variables. Sheep were able to flourish in this area because of their original adaptation to dry climate and possibly because of a lack of biological stresses such as local competition for food, parasites, and predators. Culturally, sheep provided not only an important source of meat, but also of wool. Small species whose main contribution was for meat (such as rabbit and turkey) were less favored, but species with important symbolic roles in Zuni society (wild artiodactyls and some birds) continued to be exploited and this may have played an important role in the maintenance and reproduction of Zuni cultural identity.

Kill-off Patterns

Using models proposed for herd management strategies (Payne 1973; Redding 1981) and documentary information from historic and ethnographic accounts regarding sheep utilization at Zuni Pueblo it was predicted that a mixed meat-wool economy would be present and that the archaeological samples will include remains of animals of both young and older ages (see Chapter 1).

Data derived from the analysis of tooth eruption and attrition and epiphyseal fusion patterns, analyzed in Chapter 5, suggest differences in slaughtering patterns of caprines during historic times. As indicated in the present study, age profiles derived from tooth eruption and wear provide a more accurate set of data for understanding slaughter patterns than those derived from epiphyseal fusion. However, as in many other collections, mandibular samples were far less numerous than post-cranial ones. The derivation of slaughter pattern from the analysis of fusion data was complicated by the fact that many juvenile bones could not be identified to species and were included in a general category of identification, that of deer-size artiodactyls. This provided a more general picture of artiodactyl exploitation. Generally, the age patterns implied by the mandibles correlate well with those derived from the analysis of fusion data.

Overall, kill-off patterns appear to be broadly similar in the sub-assemblages from Mission and Late Historic Periods, in that animals were mainly slaughtered at a young age, more precisely before two years of age. Data indicate an emphasis on obtaining meat from flocks during both Mission and Late Historic Periods. Animals of old age are also represented in both sub-assemblages, although in lower proportions. During the Mission Period, animals were mainly culled in their first and fourth year, a pattern that suggests a mixed economy with a focus on extracting both meat and secondary products. This type of exploitation might have served Spanish requirements for fresh lamb meat as well as for other dietary products and wool.

A shift in slaughter patterns from Mission to Late Historic times is apparent. During the Late Historic Period, data indicate a slaughtering strategy that emphasizes the culling of animals with higher intensities in their second year of life, a pattern that stresses the importance of meat. It has been suggested that since this area of the site was intimately connected to ceremonial practices, this pattern might more likely reflect a deposition of animals slaughtered for ritual activities and not the subsistence system at Zuni Pueblo. However, as discussed in Chapter 5, an emphasis on wool production cannot be excluded from the interpretation of results. In modern and ethnographic examples, herders exploit their flocks for wool production by maintaining only a third of the lamb annual crop and slaughtering the rest of the lambs not later than 15 month of age. Therefore, the deposition in the Middle Village area might very well represent the surplus of lambs killed by herders in order to sustain the flock for wool production. The annual surplus of lambs could be consumed during ceremonies, while still assuring the production of wool. In this scenario, both the economic and ceremonial purposes of the Zuni could be attained. The high involvement and level of demand for textiles in Late Historic times could have strongly influenced Zuni local production towards obtaining more wool from the flocks.

To summarize, during Spanish times, the husbandry strategy was probably based on Spanish interests for consumption and export, while from Historic times onwards, Zuni ceremonial and economic practices were important. Because the present analysis is based on faunal samples recovered from the ceremonial core of the pueblo, inferences about Zuni husbandry strategies in general cannot be drawn at this time. In other areas of the site, this emphasis on young animals might not be observed possibly because people who raise sheep tend to slaughter only barren ewes and old individuals for consumption and sell the surplus of young male lambs to the market (Olsen 1982:422). If this is true then the pattern of slaughtering in the Middle Village is more likely to reflect community activities than regular, secular aspects of Zuni life. Extrapolating, the animals slaughtered in the Middle Village might represent the surplus of males that richer sheep owners can afford to allot to religious group activities. The extent to which the specific provenience of the faunal materials may bias conclusions about general emphases in husbandry strategies and subsistence practices at Zuni Pueblo is difficult to assess because of a lack of comparable data from other areas of the site or other sites in the region.

Body Part Representations and Butchery Patterns

In terms of body part representations, the basic hypothesis was that elements of wild species that play an important role in Zuni ritual practices might be found in larger proportions in this area of the site. Wild animal products played important symbolic roles in ceremonies at Zuni Pueblo, for example through consumption of meat or through use of hides, scapulae or antlers in ceremonial clothing and adornments. The ethnographic record attests to intense ceremonial activities taking place in the Middle Village in the Late Historic Period and to the importance of wild deer-size artiodactyl products in Zuni ritual practices (Cushing 1920, Stevenson 1904).

A few trends were apparent in the analysis of body- part distributions. First, in all temporal sub-assemblages a wide range of elements and body parts of both wild and domestisc artiodactyls are represented, suggesting that whole animals were brought to or slaughtered in this area of the site. Second, an over-representation of wild deer-size artiodactyl elements associated with ritual practices was detected in the assemblage from Late Historic times. This pattern is more closely related to a cultural selection of the scapulae for ceremonial purposes because scapulae were used as rattles in ceremonies as indicated in the ethnographic record (Cusing 1920; Stevenson 1904). This idea is supported by the increase in the proportions of wild artiodactyl remains identified in Late Historic deposits. Therefore, these patterns might represent the process of retention of traditional practices that are intimately connected to Zuni identity.

Both butchery and body part information support the idea that all stages of butchery (*i.e.,* primary, secondary, and tertiary) took place in this area of the site. Butchery data also indicate that both wild and domestic artiodactyls were similarly butchered. However, ethnic differences in butchery patterns were difficult to assess due to broad similarities in the butchering process between the Spanish and Zuni traditional practices. Although the Spanish influence was clearly indicated by the adoption and use of new metal tools such as knives, axes, and cleavers, attributing the butchery process to the Spanish tradition was questionable. Faunal data correlate well with the temporal shift in the use of European metal tools *vs.* local stone tools (Howell 2003b) and provide an example where previous traditional resources were replaced by new ones. The introduction of metal tools might have produced subtle changes in the specific location and angle of cutting, but the analysis of the butchery process as a whole did not permit an accurate assessment of nuances inherent to Spanish and Zuni traditional butchery patterns. The evidence for an American influence, characterized by a more standardized pattern of carcass apportionment, was minimal in the assemblage. Consequently, the pattern of butchery in the Middle Village area more likely reflects a household, unspecialized, traditional practice in Late Historic times.

Suggestions for Future Research

This dissertation has attempted to identify diachronic changes in Zuni local dietary practices after the onset of the colonial regime. A number of factors have limited the analysis. In particular, the samples recovered from Late Prehistoric deposits were insufficient in size and impeded detailed comparisons between pre- and post-Contact components. Although fragments of smaller species were recovered, the use of 6 mm mesh has undoubtedly resulted in the loss of small animal remains, particularly of small birds, thus limiting confidence in interpretations.

This study was constrained by a lack of comparable faunal data from other colonial pueblos in New Mexico. Conversely, many of the trends identified in the current data need to be explored in more detail. Some aspects could not be explored using the zooarchaeological methodology currently available. For example, the identification of artiodactyls was complicated by the fact that bones of different species are quite similar. Distinguishing one species from another was sometimes difficult, especially when dealing with fragmentary, immature specimens, or elements with few distinguishing features (such as ribs). As a result, some analyses combine all medium-size artiodactyl specimens, which constrained the extraction of more detailed information on individual groups. Similarly, sex identifications of caprine based on morphologic criteria and metrical distributions of caprine did not provide a sufficiently comprehensive sample and were consequently not included in the analysis of population structure. The fact that mandibles cannot be sexed using current zooarchaeological methods also limited the extent to which inferences could be made on population structure. As a result, the analysis of herd management strategies had to be based solely on age data. In the same way, juvenile bones cannot be sexed or identified to species and were included in a general category of identification, which also impeded drawing more explicit conclusions on individual practices for specific groups of artiodactyls. The sexing and identification of mandibles and other post-cranial bones is a future direction to be explored in order to clarify the nature of Zuni husbandry practices proposed in this study.

Although the overrepresentation of wild artiodactyl scapulae might indicate specific cultural practices, a pattern that correlates well with ethnographic data, the nature of a taphonomic origin remains to be more intimately explored. Species identification was primarily based on articular ends with distinct anatomic features (among which scapula is easily identifiable), while most unidentifiable limb shafts and scapula blade fragments were included in the deer-size category. Assuming that the bones are mostly of sheep and goats, the possibility that a more detailed identification of the specimens might lead to slightly different results is not excluded. Additional research on the different aspects presented in this dissertation and regional comparisons would help more clearly define and evaluate the processes of change and continuity in Zuni traditional subsistence practices as well as specifically delineate idiosyncratic parameters of this particular area of the site.

Summary

The analysis of the faunal remains from the Middle Village of Zuni Pueblo reflects changes in the post-Hispanic diet, suggesting that elements of Spanish colonial foodways were adopted by the Zuni. Despite disparities in sample sizes, differences between the prehistoric and historic patterns are apparent and include a drop in the proportions of lagomorphs and turkey. The present evidence also indicates that Old World domesticates were exploited in the Old Core at Zuni as early as the time of the Missionaries. Among them, sheep seem to have landed in a favorable environment in the Zuni area. The Spanish conquistadors encountered with an environment where their homeland husbandry strategies could be maintained. Sheep, a major protein and secondary product source in the Iberian diet, became an important economic source at Zuni Pueblo.

When compared to other geographic areas (*e.g.*, Spanish Florida), the pattern of food consumption at Zuni Pueblo is very different. Domestic livestock did well in this area and the subsistence economy that emerged at Zuni Pueblo from the interaction between the Spanish colonists and the Zuni reflects a pattern of influence predicated on Spanish subsistence strategies. The new local environmental settings were favorable and allowed the colonists to retain their livestock husbandry practices. For the Zuni, on the other hand, the introduction of sheep reduced the cost of transport to and from the food source through the exploitation of resources that were readily available nearby and offered a clear economic advantage over their previous subsistence strategies. One interesting aspect of the subsistence system at Zuni, as reflected by the faunal remains from the Middle Village area, is that although this dietary system looks Spanish (with sheep being predominant), it maintains aboriginal elements in many ways. Most important is the perpetuation of hunting artiodactyls such as deer and pronghorn. This correlates well with ethnographic data on the importance of wild animals in Zuni religious life.

Overall, both change and continuity are indicated by the current zooarchaeological data. The changes that took place at Zuni Pueblo after the Spanish *entrada* reflect the adoption of Spanish livestock and subsistence practices, but also an adjustment to strategies that emphasize local economic and ritual practices. Generally, faunal data complement the analyses of material culture in the Middle Village.

Paraphrasing Reitz and Scarry (1985:99), we conclude that the Zuni modified their subsistence and cultural strategies in the following ways: 1) they abandoned some of the previous local resources with the introduction of Old World domesticates; 2) they adopted Old World species that could be raised locally and provided an economic advantage over previous resources; and 3) they maintained aboriginal patterns that were intimately connected to their cultural identity. The present study indicates a complex synthesis of indigenous and European practices. It provides us with another example of how new subsistence practices are adopted, selected, or incorporated and suggests that Spanish subsistence practices and technologies were more readily incorporated in aspects related to domestic contexts rather than ceremonial ones. The Zuni balanced the economic advantages brought by the new European introductions, while maintaining and perpetuating their cultural identity.

Finally, this dissertation brings insight into colonial dietary experience and the ways in which cultural identity is maintained and perpetuated. It provides a new set of data that can be compared to previous and future research on colonial foodways. Ultimately, this study adds to the numerous examples of processes that take place in colonial settings.

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APPENDIX A:
Frequency (NISP) of taxa from Zuni Pueblo, Waterline (after Olsen 1982)

Mammals	Taxon	Common name	NISP	% Mammal	% All Taxa
Lagomorpha	*Sylvilagus* sp.	Cottontail	30	0.54	0.53
	Lepus sp.	Jackrabbit or hare	13	0.24	0.22
Rodentia	*Cynomis* sp.	Prairie dog	7	0.14	0.12
	Neotoma sp.	Wood rat	2	0.03	0.03
	Spermophilus variegatus	Rock squirrel	4	0.08	0.08
	Spermophilus sp.	Ground squirrel	1	0.01	0.01
Carnivora	*Canis familiaris*	Dog	5	0.08	0.08
	Canis sp.	Dog, wolf, coyote	34	0.59	0.59
	Lynx sp.	Lynx/bobcat	4	0.08	0.06
	Felis concolor	Mountain lion	1	0.01	0.01
	Felis domesticus	Domestic cat	15	0.27	0.26
Perissodactyla	*Equus asinus*	Mule	9	0.16	0.15
	Equus caballus	Horse	32	0.56	0.57
	Equus sp.	Horse or mule	5	0.08	0.09
Artiodactyla	*Antilocapra americana*	Pronghorn antelope	41	0.73	0.72
	Odocoileus sp.	Deer	46	0.81	0.82
	Ovis canadensis	Bighorn sheep	3	0.05	0.05
	Odocoileus hemionus	Mule deer	20	0.35	0.35
	Odocoileus virginianus	White-tale deer	2	0.03	0.03
	Ovis aries	Sheep	71	1.24	1.24
	Capra hircus	Goat	30	0.53	0.53
	Ovis aries/Capra hircus	Sheep or goat	1782	31.35	31.16
	Bos taurus	Cattle	96	1.68	1.68
	Sus scrofa	Pig	10	0.18	0.17
	Bos/Equus	Cattle or Horse	30	0.53	0.53
	Indeterminate Artiodactyls		2261	39.77	39.54
Miscellaneous	Indeterminate Mammals		1130	19.88	19.76
		Total	5684	100	

Appendix A: Frequency (NISP) of taxa from Zuni Pueblo, Waterline (after Olsen 1982) cont'd

Birds	Taxon	Common name	NISP	% Birds	% All taxa
Falconiformes	*Buteo* sp.	Hawk	4	11.76	0.08
	Aquila chrysaetos	Golden Eagle	1	2.94	0.01
Galliformes	*Meleagris gallopavo*	Turkey	5	14.70	0.08
	Gallus domesticus	Chicken	14	41.10	0.25
Passeriformes	*Corvus corax*	Raven	4	11.76	0.08
Misscellaneous	Indeterminate Birds		6	17.64	0.12
		Total	34	100.00	
		Grand Total	5718		100

APPENDIX B:
Distribution of faunal remains by study units

SU	Late Prehistoric	Contact	Mission	Post -Revolt	Late Historic	Not dated	Total
8				49			49
10						1	1
11					11	2	13
16						116	116
17						12	12
21						6	6
24						15	15
25					88		88
27					41		43
28						43	43
31				175		12	187
37						10	10
38					57	24	81
39						182	182
40						14	14
45			1455				1455
46				427	659		1086
49			1		95	43	139
50						1	1
52				1			1
55						1	1
56						35	35
59						55	55
60						20	20
62						204	204
63						145	145
65						8	8
66						42	42
67						6	6
68			1		2	64	67
69						24	24
70						35	35
71						13	13
73					68	2	70
74					251		251
75	11	49					60
76		118				4	122
77		3					3

Appendix B: Distribution of faunal remains by study units cont'd

SU	Late Prehistoric	Contact	Mission	Post -Revolt	Late Historic	Not dated	Total
78		4					4
79		4					4
80	7	14					21
81	2	72					74
82						2	2
83	56						56
85					12		12
86			37	165	1183		1385
87				8	66	1	75
89				134			134
90	54				913		967
91			263				263
92				3			3
93				167	1010		1177
94			378	21			399
95	126	187					313
96	406	66		21			493
Total	662	517	2135	1171	4456	1142	10083

APPENDIX C:

AGEING – MANDIBLES AND FUSION

Table C1. Dental eruption and wear scores (after Zeder 1991: Tables 8 and 9)

Species	Chronology	dp4	P4	M1	M2	M3	Age
Capra	Mission		4	16	13	7	1-2 y
Capra	Late Historic	16		11	2		6-12 m
Ovis	Mission	20		17	10	2	1-2 y
Capra	Mission		20	17	17	16	3-4 y
Capra	Post-Revolt		25	25	25	18	8-10+ y
Capra	Late Historic	12		10	2		6-12 m
Capra	Late Historic		20	17	17	15	3-4 y
Ovis	Late Historic		10	17	14	7	2-3 y
Capra	Mission		20	17	17	15	3-4 y
Ovis/Capra	Not dated		17	17	16	15	3-4 y
Ovis	Late Historic	16		11	4		6-12 m
Ovis	Mission	23		17	14	3	1-2 y
Ovis	Post-Revolt		17	17	17	15	3-4 y
possible Capra	Not dated	23		17	11	2	1-2 y
Capra	Mission	20		14	4		6-12 m
Capra	Mission	20		14	3		6-12 m
possible Capra	Not dated		broken	broken	19	17	?
possible Ovis	Not dated	23		17	13	3	1-2 y
possible Ovis	Not dated		absent	26	25	20	8-10+ y
possible Capra	Not dated	23		17	11	absent	1-2
possible Ovis	Late Historic	23		16	9	2	1-2 y
possible Capra	Late Historic	23		16	11	2	1-2 y
Capra	Late Historic	23		17	13	2	1-2 y
Capra	Not dated		4	16	14	4	1-2 y
Capra	Not dated		20	26	17	17	4-6 y
Ovis	Not dated	23		17	14	2	1-2 y
possible Capra	Not dated		25	25	25	17	6-8 y
Ovis	Not dated	12		7			2-6 m
Ovis	Late Prehistoric	16		5			2-6 m
possible Ovis	Not dated		25	17	17	broken	4-6 y
possible Ovis	Not dated	19		14	3		6-12 m
Ovis	Late Historic	19		11	5		6-12 m
Ovis	Late Historic	17		7			2-6 m
Ovis	Not dated	12		9			2-6 m
possible Capra	Not dated	23		17	11	2	1-2 y
Ovis	Not dated		25	25	18	17	6-8 y
Capra	Not dated		20	absent	17	17	4-6 y
Ovis/Capra	Not dated	Absent		absent	absent	7	?
Ovis	Mission	19		10	3		6-12 m
Capra	Post-Revolt		20	25	20	17	6-8 y
Capra	Not dated	19		11	3		6-12 m

Table C1. Dental eruption and wear scores cont'd

Species	Chronology	dp4	P4	M1	M2	M3	Age
Capra	Not dated	20		11	2		6-12 m
Ovis	Not dated	23		17	14	4	1-2 y
Ovis/Capra	Late Historic		20	22	17	17	4-6 y
Capra	Not dated		25	25	25	25	8-10+ y
Ovis/Capra	Not dated	16		4			2-6 m
Ovis	Not dated		25	26	25	19+	8-10+ y
Ovis	Late Historic		20	17	17	16	3-4 y
Capra	Not dated		AW + P	26	25	18	8-10+ y ?
Ovis	Late Historic	23		17	11	2	1-2 y
Ovis	Mission		16	20	16	broken	3-4 y
Ovis	Late Historic		absent	20	17	17	4-6 y
Ovis/Capra	Late Historic	20		16	10	absent	1-2 y
possible Capra	Late Historic	20		16	4		6-12 m
possible Capra	Mission		absent	broken	16	14	3-4 y
Ovis	Mission		20	20	17	17	4-6 y
Capra	Mission		broken	25	25	broken	6-8 y ?
Capra	Mission		20	20	17	17	4-6 y
Capra	Mission		20	20	17	14	3-4 y
Capra	Mission		broken	17	17	9	2-3 y
Capra	Mission		18	17	17	9	2-3 y
Capra	Mission		18	17	17	9	2-3 y
Capra	Mission		AW + P	26	25	25	8-10+ y
possible Capra	Mission		17	17	17	15	3-4 y
possible Capra	Late Historic		AW + P	26	20	17	6-8 y ?
possible Capra	Late Historic		AW + P	26	25	17	6-8 y ?
Ovis	Late Historic		16	17	17	9	2-3 y
possible Capra	Post-Revolt	absent		16	14	2	1-2 y
Capra	Post-Revolt		25	26	25	17	6-8 y
Ovis	Late Historic	23		17	13	3	1-2 y
possible Ovis	Late Historic	23		17	14	3	1-2 y
Ovis	Late Historic		20	20	17	17	4-6 y
Ovis	Mission	21		17	11	2	1-2 y
Capra	Mission	19		16	4		6-12 m
Capra	Mission		20	25	17	17	4-6 y
Ovis	Mission	11		6	2		2-6 m
Ovis	Mission	19		11	2		6-12 m
Ovis/Capra	Mission	absent		16	2		6-12 m
Ovis	Late Historic	12		7	2		2-6 m
possible Capra	Late Historic	20		16	10	2	1-2 y
Ovis	Late Historic	20		17	10	2	1-2 y
Ovis	Late Historic	21		17	11	2	1-2 y
Ovis	Late Historic	12		7	2		2-6 m
Ovis	Mission	23		17	14	2	1-2 y
Ovis	Not dated		20	25	17	17	4-6 y
Capra	Not dated		20	20	17	16	3-4 y

Table C1. Dental eruption and wear scores cont'd

Species	Chronology	dp4	P4	M1	M2	M3	Age
Ovis	Not dated	20		17	13	2	1-2 y
Capra	Not dated		25	26	25	19	8-10 y
possible Ovis	Not dated		25	25	broken	17	6-8 y
possible Ovis	Not dated		25	26	25	17	6-8 y
Ovis	Not dated		4	16	13	5	1-2 y
Capra	Late Prehistoric	23		17	10	2	1-2 y
possible Ovis	Late Prehistoric	absent		broken	11	2	1-2 y ?
Ovis/Capra	Late Prehistoric		broken	17	17	15	3-4 y
Ovis	Late Prehistoric	16		10	2		6-12 m
Ovis	Late Prehistoric		20	22	17	11	3-4 y
Capra	Late Historic	19		11	2		6-12 m

Note: Mandibles excluded from the analysis are in bold. AW = abnormal wear; P = pathology

Table C2. Chronological distribution of mandibles by species and by age class

Age	Late Prehistoric			Mission			Post-Revolt			Late Historic			Not dated		
	O	C	O/C	O	C	O/C	O	C	O/C	O	C	O/C	O	C	O/C
0-2 months															
2-6 months	1			1						3			2		1
6-12 months	1			2	3	1				2	4		1	2	
1-2 years	1	1		4	1			1		6	3	1	5	4	1
2-3 years					3					2					
3-4 years	1		1	1	5		1			1	1			1	1
4-6 years				1	2					2		1	2	2	
6-8 years					1			2			2		3	2*	
8-10+ years					1			1					2	3*	
Totals	**4**	**1**	**1**	**9**	**15**	**1**	**1**	**4**		**16**	**10**	**2**	**15**	**14**	**3**

Note: Mandibles excluded from the analysis are underlined; * only one mandible was excluded in this category. O – Ovis; C – Capra; O/C – Ovis/Capra

Table C3.Fusion data by element part for each group through time

Element	Sheep									Goat								
	Mission			Post-Revolt			Late Historic			Mission			Post-Revolt			Late Historic		
	F	U	J	F	U	J	F	U	J	F	U	J	F	U	J	F	U	J
Scapula distal	20	2	1	5			32	1	4				2			10	1	1
Humerus distal	11		1	3		3	33		9				2			11		4
Radius proximal	11			10			40						4			17	1	
Phalanx 1 proximal	95	20	6	19	3	5	109	21	6	3	1		2	2		13	1	1
Phalanx 2 proximal	76	3	2	20	4	1	81	15	15	16	2		4	1		22	8	
Tibia distal	10	5	1	5	2		24	10	3				1			5	2	
Metapodium distal	50	15	3	7	4		32	18	2	2	1		2			5	2	
Calcaneus proximal	5	7		6	3		34	32		1				2		7	6	
Humerus proximal	2	1	2		2		2	2	5				1			3	1	
Radius distal	8	8		2	3		23	39								1	2	
Ulna proximal	3	1		2	4		10	20	1	3			3			10	3	
Femur proximal	4	1		2	1		13	5	1							3		
Femur distal	3	2	1	2		3	14	12	4							2	1	1
Tibia proximal	2	4			1		8	2	3				1			1		1
Totals	**300**	**69**	**17**	**83**	**27**	**12**	**455**	**177**	**53**	**25**	**4**	**2**	**22**	**5**		**110**	**28**	**8**

Note: F=fused; U=unfused; J=just fused

Table C3. Fusion data by element part for each group through time cont'd

Element	Sheep/Goat									Deer size artiodactyls								
	Mission			Post-Revolt			Late Historic			Mission			Post-Revolt			Late Historic		
	F	U	J	F	U	J	F	U	J	F	U	J	F	U	J	F	U	J
Scapula coracoid	1	3			1		1	3		2	1					2	12	
Humerus distal	2	1					3	1	2	1	2					5	14	
Radius proximal							1			2	3		1			3	4	1
Phalanx 1 proximal	5	27	1	3	8		2	67		5	4					2	5	
Phalanx 2 proximal	2	3		2			1	4		2			1					
Tibia distal		1			1		2	14	1	1	10			7		6	33	
Metapodium distal	2	14		1	3			16		7	36			16		5	84	
Calcaneum tuber	2				2		1	3		1	3			2			8	
Humerus proximal							1	3	2	1	8			4			38	
Radius distal					2			4			3			3			29	
Ulna proximal	1	3						6		1	2			3		2	9	
Femur proximal		5		1	4		3	8			10			7		6	40	2
Femur distal	1	2			1			8			11			4		1	42	
Tibia proximal		1			2		1	3	2		6			5			47	
Totals	**16**	**60**	**1**	**7**	**24**		**16**	**140**	**7**	**23**	**99**		**2**	**51**		**32**	**365**	**3**

Note: F=fused; U=unfused; J=just fused

APPENDIX D
BODY PART AND BUTCHERY

Table D1. MNE derivation by element and element part

Element	Description	MNE
Cranial	Whole	1
	Right or left maxilla	1
	Maxilla fragment	
	Other cranial fragment	
Antler / Horn core	Whole	1
	Fragment attached to cranium	1
	Other fragment	1
Mandible	Whole	1
	Complete tooth row	1
	Posterior to M3	0
	Anterior to P2	0
	Fragment of tooth row	1
	Fragment of tooth row + posterior to M3	1
	Anterior to P2 + fragment of tooth row	1
	Ramus fragment	0
Vertebrae	Whole	1
	Fragment (apophises)	0
	Centrum	1
	Medio-lateral split centrum	1
	Unfused epyphisis	0
Rib	Whole	1
	Dorsal	1
	Ventral	1
	Shaft fragment	0
	Ossified costal cartilage	0
Sternum	Whole	1
	Fragment	0
Scapula	Whole	1
	Fragment including glenoid	1
	Blade fragment	0
Pelvis	Whole left or right	1
	Fragment with ilium, acetabulum, ischium, and pubis	1
	Ilium fragment	0
	Acetabulum	1
	Ilium + acetabulum	1
	Pubis and/or ischium	0
	Pubis/ischium + acetabulum	1
	Other fragment	0
Long bones	Whole	1
	Proximal + half shaft	1
	Proximal + half less than shaft	1
	Unfused proximal epiphysis	1

Table D1. MNE derivation by element and element part cont'd

	Description	MNE
	Distal plus half shaft	1
	Distal plus less than half shaft	1
	Unfused distal epiphysis	1
	Shaft	0
Carpal, tarsal	Whole	1
	Fragment	0
1st, 2nd phalanges	Whole	1
	Proximal fragment	1
	Distal fragment	1
	Shaft fragment	0
3rd phalanx	Whole	1
	Proximal	1
	Distal	0
Axial, unidentifiable	Fragment	0

Table D2. Types and frequencies of butchery marks on deer/pronghorn elements

	Mission						Late Historic					
	NISP	% BT	SC	CT	CH	SW	NISP	% BT	SC	CT	CH	SW
Head and neck												
Horn Core/Antler	5	20.00	0	0	10	0	17	35.29	0	0	11	0
Skull	7	0.00	0	0	0	0	15	0.00	0	0	0	0
Mandible	2	0.00	0	0	0	0	2	50.00	0	2	0	0
Neurocranium	0	0.00	0	0	0	0	0	0.00	0	0	0	0
Atlas	0	0.00	0	0	0	0	1	0.00	0	0	0	0
Axis	2	50.00	0	9	0	0	1	0.00	0	0	0	0
Forelimb												
Scapula	10	20.00	7	1	0	0	12	0.00	0	0	0	0
Humerus	3	33.33	0	0	2	0	10	10.00	0	1	0	0
Radius	9	11.11	0	2	0	0	10	0.00	0	0	0	0
Ulna	4	25.00	5	0	0	0	12	8.33	0	0	1	0
Carpals	8	0.00	0	0	0	0	4	0.00	0	0	0	0
Metacarpal	4	0.00	0	0	0	0	4	0.00	0	0	0	0
Hindlimb												
Innominate	3	0.00	0	0	0	0	5	40.00	0	7	0	0
Femur	2	0.00	0	0	0	0	6	33.33	0	2	0	1
Tibia	3	33.33	0	15	0	0	18	0.00	0	0	0	0
Tarsals	2	50.00	0	6	0	0	6	3.33	0	9	0	0
Metatarsal	3	0.00	0	0	0	0	10	0.00	0	0	0	0
Metapodial	0	0.00	0	0	0	0	0	0.00	0	0	0	0
Foot												
1st phalanx	7	14.28	0	2	0	0	36	0.00	0	0	0	0
2nd phalanx	12	0.00	0	0	0	0	22	4.54	0	3	0	0
3rd phalanx	3	0.00	0	0	0	0	20	0.00	0	0	0	0
Total	**89**	**11.23**	**12**	**35**	**12**	**0**	**211**	**7.58**	**0**	**24**	**12**	**1**

Note: NBT = number of bones with butchery marks; SC = scrape (knife marks); CT =cut (knife marks); CH = chop (ax or cleaver marks); SW = saw (hand or electric saw mark)

TableD3. Types and frequencies of butchery marks on sheep/goat elements

	Mission						Post-Revolt						Late Historic					
	NISP	% BT	SC	CT	CH	SW	NISP	% BT	SC	CT	CH	SW	NISP	% BT	SC	CT	CH	SW
Horn Core	6	33.33	0	0	5	0	7	57.14	0	0	15	0	11	54.54	0	12	3	0
Skull	7	14.28	0	2	0	0	3	0.00	0	0	0	0	13	30.76	12	7	0	0
Mandible	29	27.58	14	17	0	0	4	0.00	0	0	0	0	33	6.07	20	3	5	0
Neurocranium	2	100.00	0	6	2	0	2	0.00	0	0	0	0	8	37.5	0	14	0	0
Atlas	6	50.00	0	7	1	0	8	0.00	0	0	0	0	19	21.05	0	37	0	0
Axis	4	75.00	0	8	0	0	8	37.50	0	2	2	0	24	12.5	0	2	1	0
Scapula	37	45.94	97	8	0	0	10	20.00	4	1	0	0	57	28.07	81	26	0	0
Humerus	20	20.00	0	19	0	0	11	18.18	0	5	0	0	97	8.24	0	28	0	0
Radius	27	25.92	0	17	0	0	21	19.04	0	7	0	1	127	12.59	0	71	4	0
Ulna	17	29.41	0	9	0	0	15	30.00	0	5	0	1	68	4.41	0	13	0	0
Carpals	26	0.00	0	0	0	0	17	11.76	0	3	0	0	43	0.00	0	0	0	0
Metacarpal	73	6.84	0	17	0	0	11	9.09	0	1	0	0	65	15.38	0	39	0	0
Pelvis	17	23.52	0	20	5	0	8	12.50	3	4	0	0	53	24.52	0	51	8	1
Femur	23	21.73	0	19	0	0	11	0.00	0	0	0	0	75	12.00	0	39	4	0
Tibia	23	30.43	6	17	0	0	13	7.69	0	2	0	0	82	8.53	0	30	2	0
Astragalus	20	15.00	0	12	0	0	12	16.67	0	3	0	0	72	8.33	0	10	0	0
Calcaneus	17	17.64	0	7	0	0	16	0.00	0	0	0	0	85	3.52	0	8	1	0
Other tarsals	40	20.00	0	18	0	0	21	14.48	0	9	0	0	59	19.04	0	31	0	0
Metatarsal	85	12.94	5	19	0	0	19	21.05	0	12	0	0	81	11.11	0	31	0	0
1st phalanx	164	0.60	0	3	0	0	45	0.00	0	0	0	0	227	0.44	0	5	0	0
2nd phalanx	105	0.00	0	0	0	0	32	0.00	0	0	0	0	147	0.68	0	2	0	0
3rd phalanx	73	0.00	0	0	0	0	17	0.00	0	0	0	0	112	0.00	0	0	0	0
Totals	**821**	**11.84**	**122**	**225**	**13**	**0**	**311**	**10.28**	**7**	**54**	**17**	**2**	**1558**	**8.48**	**113**	**459**	**28**	**1**

TableD4. Types and frequencies of butchery marks on all deer-size artiodactyl elements

	Mission						Post-Revolt						Late Historic					
	NISP	% BT	SC	CT	CH	SW	NISP	% BT	SC	CT	CH	SW	NISP	% BT	SC	CT	CH	SW
Horn Core/Antler	11	27.27	0	0	15	0	7	57.14	0	0	15	0	28	42.85	0	12	14	0
Skull	14	7.14	0	2	0	0	3	0.00	0	0	0	0	34	11.76	12	7	0	0
Mandible	32	25.00	14	17	0	0	6	0.00	0	0	0	0	41	7.31	20	5	5	0
Neurocranium	2	100.00	0	6	2	0	2	0.00	0	0	0	0	9	33.33	0	14	0	0
Atlas	7	42.85	0	7	1	0	8	0.00	0	0	0	0	22	22.72	0	42	0	0
Axis	6	66.70	0	17	0	0	8	37.50	0	2	2	0	30	10.00	0	2	1	0
Other cervical	30	6.67	0	2	1	0	18	11.11	0	8	0	0	84	4.76	0	22	4	0
Thoracic	48	12.50	0	17	5	0	23	17.39	0	1	3	0	153	2.61	0	9	3	0
Lumbar	41	17.07	0	42	0	0	34	2.94	0	5	0	0	177	12.42	0	39	12	0
Sternum	11	9.09	0	0	1	0	2	0.00	0	0	0	0	25	12.00	0	3	3	0
Sacrum	2	100.00	0	12	0	0	1	0.00	0	0	0	0	22	22.72	0	7	0	0
Caudal	17	0.00	0	0	0	0	2	0.00	0	0	0	0	10	0.00	0	0	0	0
Ribs	139	23.02	11	60	4	0	61	22.95	0	41	1	2	351	19.65	20	152	17	4
Scapula	60	31.66	104	9	0	0	11	27.27	4	2	0	0	109	17.43	87	26	1	0
Humerus	38	15.78	0	20	2	0	19	10.52	0	7	0	0	171	5.26	0	29	0	0
Radius	48	16.67	0	19	0	0	30	13.33	0	7	0	1	201	10.94	0	90	4	1
Ulna	31	19.35	5	9	0	0	21	19.04	3	5	0	1	108	3.70	0	13	1	0
Carpals	37	0.00	0	0	0	0	20	10.00	0	3	0	0	47	0.00	0	0	0	0
Metacarpal	96	5.20	0	17	0	0	19	10.52	0	1	2	0	75	14.66	0	40	0	0
Innominate	23	17.39	0	20	5	0	15	12.50	3	4	0	0	80	18.75	0	56	8	1
Femur	49	10.20	0	24	0	0	24	0.00	0	0	0	0	180	8.33	0	51	4	1
Tibia	45	20.00	6	33	0	0	30	3.33	0	2	0	0	194	5.15	0	36	0	0
Tarsals	72	23.61	0	45	0	0	51	9.80	0	12	0	0	216	9.25	0	65	1	0
Metatarsal	99	15.15	5	20	0	0	23	17.39	0	12	0	0	103	8.73	0	31	0	0
1st phalanx	182	1.09	0	5	0	0	52	0.00	0	0	0	0	271	0.36	0	5	0	0
2nd phalanx	120	0.00	0	0	0	0	36	0.00	0	0	0	0	170	1.17	0	5	0	0
3rd phalanx	78	0.00	0	0	0	0	21	0.00	0	0	0	0	133	0.00	0	0	0	0
Totals	**1338**	**12.56**	**145**	**403**	**36**	**0**	**547**	**10.60**	**10**	**112**	**23**	**4**	**3044**	**9.00**	**139**	**761**	**78**	**7**