Costly Signaling and Changing Faunal Abundances at Five Finger Ridge, Utah

Jacob Levi Fisher

A dissertation submitted in partial fulfillment of
the requirements for the degree of

Doctor of Philosophy

University of Washington

2010

Program Authorized to Offer Degree:
Anthropology

University of Washington

Graduate School

This is to certify that I have examined this copy of a doctoral dissertation by

Jacob Levi Fisher

and have found that it is complete and satisfactory in all respects,
and that any and all revisions required by the final
examining committee have been made.

Chair of the Supervisory Committee:

____
Donald K. Grayson

Reading Committee

____
Donald K. Grayson

____
J. Benjamin Fitzhugh

____
Peter V. Lape

____
Eric A. Smith

Date: _____________________________________

Signature ____________________________

Date ________________________________

University of Washington

Abstract

Costly Signaling and Changing Faunal Abundances at Five Finger Ridge, Utah

Jacob Levi Fisher

Chair of Supervisory Committee:
Professor Donald K. Grayson
Department of Anthropology

This research attempts to develop and test a series of predictions for identifying costly signaling forms of hunting in the prehistoric past. I predict that signaling hunters should place increasingly greater value in species that have become more rare on the landscape, while non-signaling hunters should respond by increasing their diet breadth. These animals may be identified from the archaeological record using taxonomic and skeletal part abundance measures combined with strontium isotope values to show that hunters were traveling further abroad when local populations became locally scarce. Since species with high signaling value should be widely shared in order to maximize the hunter's signal to a broad audience, I also argue that taxonomic and skeletal part richness and evenness measures may be used to distinguish different forms of sharing.

I used the fauna from Five Finger Ridge, a Fremont site in the eastern Great Basin, to test these predictions. I found that density-mediated bone survivorship varied across taxa and site contexts, preventing the identification of behaviorally-meaningful patterns in household faunal assemblages. This finding demonstrates the importance of incorporating density-mediated destruction analyses in evaluations of taxonomic abundance measures. For the assemblage as a whole, I discovered significant fluctuations in the relative abundances of three leporid species (Nuttall's cottontail, desert cottontail, and jackrabbits) and mountain sheep that appear to be related to climate change at the end of the Fremont Period. Strontium

isotope data demonstrated that new sources of mountain sheep were used when environmental conditions became unfavorable to local populations. I also documented that later hunters at Five Finger Ridge were traveling to more distant locations to acquire large game using body part abundances and strontium isotopes.

This research attempts to expand the ways that archaeofaunal data are used for understanding prehistoric foraging decisions within a social context, while pushing methodological limits by extending the use of skeletal attrition and strontium isotope analyses. This research also provides significant data for understanding of the biogeography of a number of mammals and their responses to climate change in the past and present.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

This dissertation would not have been possible with the assistance provided by numerous individuals. Special thanks go to my committee chair, Don Grayson, who has provided support in ways that extend beyond that of a dissertation advisor, guiding me through the intricacies of graduate school and the development of my professional carreer despite his own hardships. My supervisory committee, Ben Fitzhugh, Peter Lape, and Eric Smith, have all provided me the necessary tools for carrying out this research through advice, instructorship, and friendship.

This research could not have been executed without the assistance of those who provided collections, comparative materials, and labs. Special thanks go to Kari Carisle, curator at Fremont Indian State Park, who was invaluable in providing access to the Five Finger Ridge assemblage and gaining permissions to conduct destructive analysis for strontium isotope research. Dr. Joel Janetski and Richard Talbot both provided essential data on the site and assisted in acquiring permissions to use the collection. Jeff Bradley, Mammalogy collection manager at the Burke Museum of Natural History and Culture, made available comparative materials for fauna identifications. My appreciation for the lab time, guidance, and analysis conducted by Dr. John Krigbaum and Ben Valentine of University of Florida extends beyond words. Without their assistance, the isotopic analyses could not have been done.

My fellow graduate student colleagues provided friendship and guidance throughout my graduate career, and I would not have survived without them. At risk of leaving out

individuals, these include Shelby Anderson, Dr. Phoebe Daniels, Dr. Michael Etnier, Jack Johnson, Stephanie Jolivette, Becky Kessler, Lisbeth Louderback, Margaret Burger, Emily Peterson, Colby Philips, Dr. Brooke Scelza, Amanda Taylor, James Taylor, and Dr. Catherine West. Undergraduate students Lindsey Tibke, Dana Kubilus, and Meriah Dainard assisted in organizing and analyzing portions of the assemblage, and I enjoyed teaching them the intricacies of faunal research.

Finally, my greatest thanks are extended to my family. My wife Kim has supported my graduate career for reasons unbeknownst to me, pushing me to continue on when no end was in sight. Her unconditional love provided the support I needed throughout the years. And while she has yet to know it, my daughter Zoey has managed to put a smile on my face for the past year as I completed my dissertation research, and I love her “to the moon and back” for doing so. I also thank my mother, who provided a house full of anthropology books, and my father, who showed me the outdoors and love for knowledge, both of whom transformed me into the archaeologist I am today. I must not forget Michael Elliott here, my brother in archaeology, who has been indispensable as a critical force for guiding my career.

This research would not have been possible without funding to acquire the collections and conduct the isotopic analysis. This research was supported by a National Science Foundation Dissertation Improvement Grant (#0840847), a Wenner-Gren Foundation Dissertation Fieldwork Grant, University of Washington Earth and Space Sciences pilot funds, and Utah State funds.

Chapter 1

INTRODUCTION

1.1 Introduction

Between 2002 and 2010, a series of papers appeared debating the role of large game hunting in the California Middle Archaic (Broughton and Bayham 2003; Codding and Jones 2007; Grimstead 2010; Hildebrandt and McGuire 2002, 2003; Hockett 2005; McGuire and Hildebrandt 2005; McGuire et al. 2007). The debate sparked an increased interest in the potential role of costly signaling as a primary motivation for male hunting and how archaeologists might disentangle decisions based on optimal foraging and signaling forms of hunting from the archaeological record.

This dissertation research was formulated around a number of questions that developed out of the interchange that followed from Hildebrandt and McGuire's initial proposition. How can we identify costly signaling hunting among small-scale societies? What conditions would have allowed for signaling forms of hunting? And why have predictions formed from optimal foraging models worked so well in application if hunting was motivated by costly signaling and not basic energetic needs?

Here, I attempt to answer these questions and form fully testable models for costly signaling that can be applied to the archaeological record. Doing so allows us to expand the archaeological applications of human behavioral ecology framework from the relatively simple optimal foraging models that were introduced over twenty years ago (e.g., Broughton

1994a; Szuter and Bayham 1989) to include a larger spectrum of currencies that may be used by foragers for determining resource use. Doing so also allows us to untangle different decision-making processes made according to sex and age, as well as factors such as prestige-seeking, that ultimately evolved to maximize evolutionary fitness.

1.1.1 The Failure of the Provisioning Model

Among hunter-gatherers and other small-scale societies, the household is the most basic economic unit and is frequently characterized by a sexual division of labor that allows for maximum consumption benefits to the household. The traditional argument has been that doing so allows each to contribute necessary dietary components to their household. Men focus much of their foraging time on hunting, provisioning their families with high protein and fat resources that are so critical to human growth and sustenance, while women gather more local and predictable plant resources (Bird 1999; Brown 1970; Hawkes 1996; Jochim 1988; Kaplan et al. 2000; Marlowe 2007; Panter-Brick 2002).

Models derived from optimal foraging theory (OFT) may be used to predict the resources that should be contributed by women and men to provision their households. The prey choice model, also known as the diet breadth model, predicts that high ranked resources should always be acquired on-encounter, and that the inclusion of lower-ranked resources will depend on encounter rates with those that are higher ranked. The most common currency used by ethnographers to rank prey has been post-encounter energetic gains, while archaeologists use body size as a proxy for energy due to the inability to estimate search and handling costs. Similarly, the patch-choice model is used to predict how long an individual should continue to forage a clumped resource before shifting to an alternative resource based on the return rates of the present patch compared with the estimated costs of shifting to the new location.

It has become increasingly clear, however, that the simplicity of the provisioning models does not adequately explain why men target particular prey items. For one, men frequently target large game, and while these provide high caloric returns, they are accompanied by relatively high associated search and opportunity costs (e.g., Bird et al. 2009; Hawkes 1996). Large bodied prey tend to be associated with relatively low population levels, a consequence of larger range requirements, slower gestation and maturation rates, and fewer offspring. This results in longer search times and a greater chance at returning empty-handed. In other words, large game hunting is often a boom-or-bust activity, and the high variation in success makes this activity relatively risky. If the goal is to provision the household, men might be better off targeting smaller, more frequently encountered prey, including plant resources.

Another shortcoming of the provisioning model is that the large game frequently pursued by men are shared beyond their own household. Sharing large, asynchronously acquired resources may be explained in part by risk reduction reciprocity. While large game hunting is risky, distributing the resource beyond a hunter's own household ensures that future captures by other hunters are shared in return. However, this assumes that variation in success is evenly distributed among men, but it is clear that this is not the case. "Good" hunters have higher rates of foraging success, and they continue to hunt and share their captured resource even when their household does not receive any direct reciprocal benefits.

The distribution of meat also does not always favor the successful hunter's household, and prescribed rules for sharing may also preclude reciprocity as the hunter has little control whether contributions are targeted towards reciprocating households. One has to question then why some men continue to pursue asynchronously acquired resources if they are going to be treated as public goods when smaller but more predictable resources would be more beneficial to their own household.

This is not to say that hunters are not provisioning their household at all, but that they may be simultaneously receiving other benefits as well. There is no doubt that provisioning animal resources through the sexual division of labor has significant benefits to women and children (Gurven and Hill 2009). For example, Hadza hunters produce more food when they are providing for their own children than when providing for stepchildren, suggesting that provisioning is an important component of hunting (Marlowe 1999). Furthermore, even good hunters are impeded by occasional illness and decreased capacity due to aging, and their generosity may payoff in the long run through delayed reciprocity may be critical for the survivorship of their spouses and children. However, while provisioning may be important goal, it does not explain why some men choose particular animals, including those that are rare, dangerous, or otherwise have high variability in success, in order to supply meat to their households and others. Nor does provisioning their existing spouses and children preclude other pursuits, including seeking additional mating opportunities.

Lastly, the basic provisioning model posits that men hunt in order to provide protein and fat resources, yet women are frequently capable of provisioning themselves and offspring with these resources themselves. Women participate in both active and passive forms of hunting of mobile animals, and a number of sessile animal and plant resources, such as shellfish and nuts, are an important contribution to many diets. This is especially the case when food resources are plentiful and can be obtained by one sex successfully, which could potentially break down the cooperative unit based on sexual division of labor. Human behavioral ecology has been used to argue that women focus their foraging energy on these resources because they are predictable—there is a low variation in success, which is necessary for ensuring that their families have food and thus critical for their individual evolutionary fitness (Bird 1999).

Indeed, long-term fitness benefits may be driving the foraging decisions of men and women in the two different directions, but not necessarily through basic provisioning of their offspring. Since the genetic certainty of offspring is always known for females, they benefit from provisioning their children. However, even with the long-term pair bonding seen in human societies, men have not been able to determine paternal certainty until the recent advent of genetic testing. Consequently, they may benefit more from increasing the number of mating opportunities instead of focusing on provisioning potentially children fathered by other individuals. Parental investment also differs between the sexes due to the significantly longer investment times involved in pregnancy and childrearing for women, while some men could potentially invest in genetic material and nothing more. In other words, long term pair bonds do not necessarily benefit both sexes equally, and monogamy may break down when parenting results in lost mating opportunities. Fathers may seek new mating opportunities while providing for their children as well. Recent work by Smith and his colleagues (Smith et al. 2003; Smith 2004; Gurven and von Rueden 2006) support this case, as highly successful hunters tend to have more mates and children attributed to them.

1.1.2 Costly Signaling and the Show-Off Hypothesis

The inconsistencies of the provisioning model for the sexual division of labor suggest that some food resources have value beyond nutritional benefits that allow for some men to have higher reproductive success. Recently, costly signaling theory has been adapted from evolutionary biology to provide a framework for understanding some counter-intuitive behaviors (Bliege Bird and Smith 2005; Maynard Smith and Harper 2003; Spence 1973; Veblen 1994 (1899); Zehavi 1975). The basis of the theory is that individuals vary in underlying attributes that are difficult to observe, and individuals who are of higher underlying quality have a higher capacity to assume the costs ("handicaps") of signaling their quality. Observers of the signal benefit by correctly reading the signal and responding accordingly, although they may have conflicting interests with the signaler.

Due to the variation in success for hunting some game resources, men with an underlying trait desired by potential mates and allies are more likely to have success. Some men choose to hunt particular game despite possible lower net energy returns and higher risks because it serves as a quality-dependent signal. This suggests that values such as rarity or difficulty in securing particular prey underlie some prey-choice decisions, rather than the energy-based currencies used in most prey-choice models. For instance, among Meriam Islanders, hunters who take turtles when they are relatively difficult to capture appear to have higher prestige and reproductive success (Smith, et al. 2003). In contrast, during the nesting period, turtle collection can be done by anyone in the community, and collection success provides no quality-dependent information.

The underlying attribute may simply be foraging capacity, which may be a critical asset to some observers. Women in particular may benefit from reading this signal correctly by selecting men who can reliably provision their household when their own foraging capacity is limited by pregnancy or young children (Marlowe 2003), while the signaler gains additional mating opportunities. Hunters often share meat well beyond their own household, and this display demonstrates to a wide audience the ability to provide private goods (Gurven 2004a), and establishes ongoing relationships with specific receivers. Even though gossip may reliably distribute a signal instead of widespread sharing (Smith comment in Gurven 2004b), food sharing plays an integral role in acquiring and maintaining future cooperative partners (Gurven response in Gurven 2004b).

Benefits from signaling may include prestige-formation that is not directly related to mating effort. Henrich and Gil-White (2001) explain why people admire and defer to successful, skilled individuals, why such individuals desire to be prestigious, and why people pay attention to those to whom others give prestige. Because people can always shift their deference, the distribution of prestige will have an aspect of a market. One way that individuals can signal their success aside from using skills alone is through physical items. Prestige goods may be used to demonstrate skills in hunting, craft production, or knowledge about the environment, as well as the quality of the individual's social contacts (important during times of environmental stress).

When applied to hunting, costly signaling theory differs from the earlier show-off hypothesis (Hawkes 1990; Hawkes 1993a; Hawkes 1996; Hawkes and Bird 2002), which also argues that men hunt risky game for social or mating benefits. For one, costly signaling does not require tolerated scrounging-based sharing, which is present in the show off hypothesis by its focus on large game. Secondly, costly signaling avoids the second-order collective action problem of who should reward generous hunters. Instead of supposing that the hunter receives some form of payback from potential mates and allies, costly signaling argues that the receivers and signaler both benefit from the signal being observed correctly.

1.1.3 The California and Great Basin Middle-Late Holocene Transition Debate

Although previous research used costly signaling and related evolutionary models for explaining changes in the archaeological record (e.g., Neiman 1997), Hildebrandt and McGuire (2002) were the first use the theory with faunal data in an effort to more completely understand the underlying motivations for large game hunting. Citing ethnographic work on costly signaling (e.g., Bird 1999; Hawkes 1990; Hawkes 1993a, b), Hildebrandt and McGuire argue that the increasing numbers of artiodactyl remains found in assemblages dating from 4000 to 1000 BP, a time as human population growth, may not represent decisions made according to the prey choice model derived from optimal foraging, which predicts that diet breadth will expand and contract according to relative population levels of high and lower ranked prey. The high frequency of artiodactyl remains corresponds with increased use of obsidian for producing hunting equipment, as well as an influx of rock art and other representations of artiodactyls, suggesting that large game hunting was taking a more prominent position in Middle Archaic societies. Hunting large game may instead be motivated by non-dietary social benefits that result in higher evolutionary success among good hunters. The authors also argue that the faunal assemblages from Pie Creek Shelter, Nevada, do not follow the prey choice model, indicating the either that the model itself is flawed or that costly signaling is driving many foraging decisions (McGuire et al. 2004; McGuire and Hildebrandt 2005).

In response to Hildebrandt and McGuire (2002), Broughton and Bayham (2003) responded that the increased number of artiodactyl relative to leporid remains in Middle Archaic assemblages is more parsimoniously explained by climatic amelioration during the same period. The middle Holocene (ca. 8000 to 4000 BP) was characterized as a hot and dry period throughout western North America (e.g., Benson et al. 2002; Grayson 2000, 2002, 2006b; LaMarche 1973; Lindstrom 1990; Louderback and Rhode 2009; Negrini 2002; Thompson 1992), and the shift to the early portion of the Late Holocene (ca. 4000 to 2500 BP) brought cooler and wetter conditions that likely would have resulted in increased artiodactyl population levels. The change in the relative abundances of artiodactyls to leporids in archaeological assemblages at this time are argued to be simply a reflection of their overall abundances on the landscape; as per the prey-choice model, such an increase in population would result in higher encounter rates, leading to greater frequency of artiodactyl remains as lower return species are ignored at a higher frequency.

For the Great Basin, Hockett (2005) points out that the difficulties inherent in attributing site components to the middle and late Holocene is oversimplified by McGuire et al. (2005) and Byers and Broughton (2004). He notes that the compartmentalization of time may greatly influence the relative frequencies of taxa, depending on what date is used to mark the transition to the late Holocene. He instead advocates the use of three time periods: 8500-5000 BP for the middle Holocene and 4000-present for the late Holocene, with the millennium between the two representing a transitional period. Using depositional rates of faunal remains instead of the Artiodactyl Index used by previous researchers, Hockett argues that artiodactyl hunting was *more* important to middle Holocene economies than noted by Byers and Broughton (2004) for sites located at middle-to-upper elevations (above 5000 feet asl). At Pie Creek Shelter, depositional rates of artiodactyls show no change through time, contrary to previous research based on a different measure (the "Artiodactyl Index," discussed in Chapter 3). In addition to the data on depositional rates, Hockett also provides evidence based on projectile point frequencies and prehistoric corrals that the transition between the middle and late Holocene is marked by increase use of communal hunting methods for large game, principally pronghorn (*Antilocapra americana*) in the Great Basin by larger groups of foragers.

This supports Hildebrandt and McGuire's (2002) argument for social reorganization at the onset of the late Holocene, but the lack of change in artiodactyl deposition rates during this period suggests the absence of both large game hunting intensification and artiodactyl population increases at this time. There is, however, an increase number of small game, principally leporids, during the Late Holocene, and together these data suggest that there was no resource depression, but instead resource intensification to meet the needs of larger human populations. However, Hockett's use of annual depositional rates in place of the Artiodactyl Index may be problematic, especially with relatively limited number of dates. It assumes that the frequency of site use was regular over long periods of time, yet deposits may instead represent a smaller number of less frequently occurring foraging episodes.

While Broughton and Bayham (2003), Byers and Broughton (2004), and Hockett (2005) have pointed out the empirical flaws in Hildebrandt and McGuire's (2002) interpretation of the faunal record, Codding and Jones (2007) focus on issues surrounding the application of costly signaling theory. They appropriately note that demonstrating the presence of costly signaling prehistorically requires showing that large game necessitated high relative costs and resulted in higher reproductive success, and that dietary alternatives were present but systematically passed up in favor of large game (Codding and Jones 2007). Hildebrandt and McGuire (2002) assume the presence of these conditions based on their presence among some ethnographic foragers, despite the fact that the motivations for some hunting are still not clearly attributable to costly signaling behaviors. Instead, Codding and Jones point out ethnographic cases where large game may be preferable, but hunting still follows the predictions derived from optimal foraging theory. Even if men were targeting some prey species for signaling purposes, the faunal assemblages are likely dominated by activities of non-signaling foragers.

Codding and Jones use the case study of Meriam turtle hunters (Bliege Bird et al. 2001) as an example of the complexities involved in demonstrating the presence of costly signaling archaeologically based simply on the presence of a single species known to be used for signaling hunting. As I have noted, sea turtles are acquired at two different times of the year using differing techniques, and the subsequent role of turtles in the Mer social organization varies accordingly. When turtles are hunted off-shore during the feeding/mating season, they are consumed during feasts. Bliege Bird et al. (2001) have shown that individuals associated with high hunting success at this time tend to have potentially higher reproductive success—more children are attributed to “good hunters”, although genetic relationships have not yet been demonstrated. On the other hand, a larger number of turtles are acquired during the nesting season on-shore at comparatively lower risks and costs, and this activity is not associated with any form of prestige. Unfortunately, Codding and Jones argue that it would be difficult to discriminate these two events archaeologically.

McGuire and his colleagues (2007) responded to Codding and Jones critique largely by noting that giving in to an inability to demonstrate reproductive success resulting from signaling behaviors and the complexities of unraveling signaling hunting from foraging based on optimal foraging theory would result in an unproductive, “no-can-do” archaeology. Returning to the turtle hunting example, they note that signaling might be identified archaeologically be evaluating the spatial contexts and sex ratios of the remains. Similarly, artiodactyl remains do appear to be more frequent in ceremonial structures among the Fremont of Utah, and that artiodactyls are more frequent among larger, more complex Fremont sites. In addition, they provide data for Owens Valley, California, sites to show that mountain sheep (*Ovis canadensis*) hunting and the use of logistical upland sites increased during the Middle Archaic. Using least-cost pathway analysis combined with presumed travel time, they demonstrate that the costs of upland sheep hunting exceeded those of small game that are more local and abundant due to r-selected reproductive rates.

Grimstead (2010) modeled the travel and transport costs for black-tailed deer (*Odocoileus hemionus*), antelope jackrabbit (*Lepus alleni*), and desert cottontail (*Sylvilagus* *auduboni*) obtained between 0-200 km from a central place to demonstrate that non-local large game hunting still follows the expectations derived from optimal foraging theory, contrary to McGuire et al. (2007). Instead of depending simply on travel time, Grimstead uses a larger number of variables based on bioenergetics to evaluate the travel cost to a resource as well as the costs when transporting a load back to the central place. She concludes that large game remains a high-return prey item even with high travel distances; a 141 kg artiodactyl procured within 200 km would produce the equivalent return of 31 jackrabbits acquired within 1 km. As such, it is more likely for small game acquired non-locally to be a costly signal than large game.

However, one critical element of optimal foraging, search costs, is not considered by Grimstead as a critical element in central place foraging. Larger-bodied prey are typically rarer on the landscape, requiring hunters to spend a large time searching or waiting at designated locations (e.g., hunting blinds) for prey. As I have mentioned, the relative rarity of larger-bodied prey frequently results in higher variance in success and is likely related to the higher search times involved. Thus, while the actual costs of traveling to patches that contain prey and transporting the captured animal back to a central base may not be high enough to lower their ranking compared to more local small-bodied prey, the time between traveling and capture (if successful) may be relatively high. One has to question whether the opportunity costs then exceed the returns for such large-game hunting. Furthermore, small game may be acquired using passive methods, such as trapping, that may be embedded in other activities, thereby reducing the travel costs.

Grimstead also assumes an individual hunter, while large game hunting may involve small groups of men working collectively (Lowie 1924; Steward 1933, 1938). This certainly would have increased the costs significantly, although it may have reduced the variance in success in some circumstances. The model also ignores other elements, such as slope, that would greatly increase travel costs for upland species, such as mountain sheep. Even if these omissions are ignored, Grimstead's conclusion that a single, non-locally procured artiodactyl would provide equal returns to a larger quantity of local small game still does not explain why a hunter would choose to target one over the other. The underlying behavior may still involve costly signaling, although the prey item that is the signal could either be the single artiodactyl from 200 km or the thirty-one jackrabbits from 1 km (e.g., Lupo and Schmitt 2002). Instead of assuming that large game are a signal *a priori*, the conditions predicted by signaling theory must in turn be used to predict what kinds of prey should be targeted by signaling and non-signaling hunters. Grimstead takes the right path by modeling when larger game would be energetically more advantageous regardless of travel distances, but more variables need to be considered in such a model.

Regardless of the "no-can-do" attitude perceived by McGuire et al. (2007), Hildebrandt and McGuire (2002) clearly sparked an interest in identifying how human behavioral ecology might be expanded beyond optimal foraging models in archaeological contexts, and more broadly speaking, how archaeologists can make the bridge from high level theory to empirical reality. Much has been learned from the ensuing discussions, including how to control for equifinality and the assumptions made regarding the costs of large game hunting. It is time now to move beyond the critique to formulating testable expectations that are tightly derived from costly signaling theory and apply these to the archaeological record.

1.2 Modeling Signaling Hunting among Prehistoric Societies

If our goal is to understand the prehistoric foraging behaviors that resulted in the archaeological record, recent ethnographic work (Bliege Bird, et al. 2001; Smith, et al. 2003) suggests that we must expand beyond optimal foraging models and build the tools needed to examine the role costly signaling played in past societies. The four conditions for costly signaling identified by Bliege Bird and Smith (2005) provide a starting point for developing explicit expectations that can be applied to a variety of archaeological contexts. First, individuals vary in some underlying attribute that is difficult to directly observe but can be reliably signaled. Second, observers of the signal benefit from correctly translating the signal to the underlying, desirable trait. Third, the signaler and recipient have conflicting interests, as deceptive signals would benefit the signaler at the cost of the observer. Lastly, the signal cost or benefit must be quality-dependent, allowing higher quality signalers to incorporate lower marginal costs or higher marginal benefits than lower quality signalers.

In the following, I will develop a series of predictions concerning what kinds of faunal resources should be used as signals by small scale foraging societies to identify good hunters that may be selected as a mate or ally. I will argue that individual carcasses of species that are the most effective signals are more likely to be distributed widely between households within an archaeological site, and that this distribution should change through time as specific prey lose or gain value as a costly signal.

As a starting point, I assume that costly signaling among humans is present across time and space as a result of individual competition over resources (e.g., mates, allies), but the form that it will take is dependent on context. Signaling behaviors benefit both the sender and receiver of the signal, and it is expected that the type of signal used will change according to what underlying traits are deemed valuable to the receiver. Although it is not clear what the hidden quality may be, I will assume that costly signaling forms of hunting involves an overall commitment and capacity to supply surplus resources to mates, children, and allies, and possibly other desirable traits, such as strength and skill. As such, signaling should be present within the subsistence realm as long as it is an effective means of honestly signaling valued qualities.

To adapt the four conditions of costly-signaling (Bird and Smith 2005; Smith 2004) to hunting, individuals (1) must have differential abilities in hunting success, (2) must share the acquired meat to create a wide audience and for receivers to accurately obtain information about the signaler that cannot be directly observed, (3) must have conflicting interests with the recipients, and (4) must hunt prey that are quality-dependent. On the basis of modern observations, the first and third condition will be assumed to exist archaeologically.

1.2.1 Archaeology of Interhousehold Transfers

Game targeted by the hypothetical signaling hunter is frequently distributed to others in ways that have not been sufficiently explained by other models of sharing alone. The consequences of various modes of resource redistribution are predicted to result in discrete archaeological signatures based on previous ethnoarchaeological research (e.g., Lupo and Schmitt 2004) and modeling (Gurven 2004a).

Recent ethnoarchaeological research among the Congo Basin Bofi by Lupo and Schmitt (2004) identified different forms of sharing between households correlating with costly signaling and provisioning behaviors. Among the Bofi, communal net hunting is a high risk and high cost activity, and the captured items are distributed broadly with some participants of the hunt receiving no shares (Lupo and Schmitt 2002). In contrast, individual hunting targets a wider variety of species with less risk and fewer costs. The results are treated as a private good that can be shared according to successful hunter's own wishes. These observations follow the expectations of optimal foraging and costly signaling. Provisioning fathers should not target specific prey based on signaling value, but instead acquire prey according to net energetic returns, while signaling hunters are more likely to forgo hunting lower ranked prey items when encountered in hopes of capturing the targeted items that have high signaling value. Accordingly, it is expected that middens of households consisting of provisioning men should be characterized by high taxonomic richness resulting from the capture of prey that have low signaling value. In contrast, the targeting of specific prey by signaling hunters would result in lower taxonomic richness of their households. However, signaling hunters may also acquire fallback species on encounter if their attempt to capture the targeted species fails, and they may also receive meat through other forms of interhousehold exchanges. The inclusion of additional species may raise the taxonomic richness of the household, but it should still be dominated by a smaller number of taxa—those species that are valued highest for signaling.

These patterns may be obfuscated by the blending of multiple sharing events, not all of which involve costly signaling. Sharing beyond one's household may also result from a number of alternative mechanisms, such as kin selection, tolerated scrounging, risk reduction reciprocity (Hawkes 1992; Trivers 1971; Winterhalder 1986, 1996), coalitional support (Patton 2005), or a combination of these factors (for review, see Gurven 2004b; Hawkes 1992; Kelly 1995; Wiessner 2002). Tolerated scrounging occurs when an individual requests food with no intention of reciprocating. This model argues that sharing will occur in this manner only when the cost of retaining a resource is greater than the benefit of sharing it. As previously discussed, risk reduction models suppose that there are daily variances in the ability to harvest resources. The variance must be low enough that an unsuccessful forager is compensated by another, more successful forager, with the underlying knowledge that the daily variance affects all equally, and the successful hunter may be unsuccessful at the next hunt (Gurven 2004a, b, 2006).

Gurven's (2004b) model of reciprocity, scrounging, and signaling forms of sharing evaluates the depth (the amount of a resource that is kept) and breadth (the number of recipients) of sharing. Since depth measures how much of a package is kept by a household, this can be used to form household-level predictions for skeletal part evenness and richness while considering the influence of breadth. For instance, if a larger portion of a resource being kept (high depth), skeletal part evenness and richness should likewise be high.

Reciprocity may be distinguished from scrounging and signaling by the limited breadth of sharing, as families should only exchange with those who are likely to engage in reciprocal behavior. A single network of reciprocating partners should be restricted to a smaller number of recipients than the total number possible (Gurven 2004b). Cumulatively, as families continue to reciprocate with one another through time, their household midden should come to have similar skeletal part richness and evenness values. Yet these household assemblages should not only contain the products of their own and reciprocating partners' foraging activities, but also contributions made by signalers. This assumes reciprocation of like resources in a tit-for-tat model; exchange of non-like resources or when using value instead of quantity may result in mixed evenness measures between reciprocating households. The high breadth and low depth of sharing by signalers should result in low skeletal part evenness and richness for those species with high potential signaling value. In contrast, tolerated theft should result in carcass segments with high utility being retained and the remaining segments being shared, resulting in an uneven distribution of elements.

The combined predictions derived from Lupo and Schmitt (2004) and Gurven (2004b) for individual household faunal assemblages are presented in Table 1.1. While more than one mechanism may be responsible for a particular pattern, none of the mechanisms share the full suite of characteristics. I recognize that this categorization of behaviors masks variation in individual decision-making that likely varies between the extremes of "provisioning" and "costly signaling". Such variation is expected to be present between individuals, as well as within individual life histories.

This series of predictions is probably best applied to archaeological contexts deposited during relatively limited time spans that do not cross-cut individual life history changes. Foraging capacity varies not only between individuals, but within an individual's lifespan. In a review of daily energy acquisition for individuals among the Hiwi, Ache, and

Hadza, Kaplan and colleagues (2000) found that adult men obtain more food than any other age-sex category, peaking at around 30-35 years of age due to the large amount of skills that must be learned in order to be a successful hunter. Furthermore, the acquisition rates exceed consumption rates for adult males; although the authors lean strongly towards a provisioning argument, they do not specify to whom this surplus is being distributed (i.e., their own household versus women and children as a whole).

The predictions I have offered also assume that transfers occurred in the context of households (i.e., houses), but signaling hunting may involved public feasting in non-domestic contexts. Such locations may be identified by the dominance of species targeted by signalers, and the conspicuous low frequencies of these species in domestic contexts. Furthermore, an argument would have to be made using independent data to show that the species present in such contexts carried a high signaling value (see Section 1.2.2).

Few other archaeologists have attempted to identify sharing of faunal resources between households (Enloe 1991, 2003, 2004; Enloe et al. 1994; Marshall 1993, 1994; Parmalee and Klippel 1983; Yellen 1977), and fewer yet have attempted to understand such sharing using a behavioral ecology framework. Waguespack (2002) evaluated whether scrounging or reciprocity was driving interhousehold transfers using similar predictions on skeletal part evenness and richness combined with mechanical and anatomical refitting. In her analysis of two households at Palangana, a historic Nunamiut site in Alaska, she found an uneven distribution of skeletal parts, leading her to conclude that scrounging was the principle cause of sharing. Her analysis was simplified by the use of an historic assemblage consisting primarily of a single taxon (caribou) with exchanges between only two households. Unfortunately, refitting methods used by Waguespack and Enloe (Enloe 1991, 2003, 2004; Enloe, et al. 1994) are time consuming, require completely excavated assemblages, and relatively pristine skeletal material that has witnessed minimal taphonomic impacts. Additionally, the assumptions of symmetry in anatomical refitting may be invalid (Lyman 2006).

1.2.2 A Costly Signaler's Prey Choice Model

One of the expectations for distinguishing modes of sharing is that taxa with high signaling value should be distributed indiscriminately among households in the process of forming an audience. The value of such taxa must be such that only some individuals—men who possess the critical underlying trait that is of value to the receiver—are capable of absorbing or avoiding the costs. In other words, the costs of pursuing and successfully capturing these prey should correspond with the hunter's capacity, and hunters should vary in this capacity. These qualities may include the relative difficulty of acquisition caused by the population density of the prey, incurred costs due to the hunting method, or behavioral mechanisms used by the prey in response to predators, such as speed and aggression.

The fine-grained prey choice model (Stephens and Krebs 1986) is frequently utilized by anthropologists to evaluate diet-breadth (see reviews in Cronk 1991; Kelly 1995; Smith and Winterhalder 1992). Using net energy as the currency to rank resources on an ordinal scale, it is expected that individuals should dispatch high-ranked prey items on encounter. Lower ranked prey are incrementally added to the diet according to encounter rates with higher ranked prey. A corollary to this expectation is that changing population densities of higher ranked prey resulting from overhunting (i.e., resource depression) or deteriorating environmental conditions favorable to the species will lead to an increased focus on lower ranked prey items and often to increased diet breadth (such a model does not necessitate increased diet breadth, as foragers may instead capture a larger quantity of a single lower-ranked species). Large-bodied vertebrates—frequently the highest-ranked prey available—are particularly susceptible to overhunting due to their relatively longer gestation times, smaller litter sizes, and slower growth rates to maturity compared to smaller taxa. The archaeological record has proved valuable for identifying changing diet breadth in response to resource depression by providing a temporal component generally unavailable to synchronic ethnographic studies (e.g., Broughton 1994a, b, 1997; Broughton 2001; Butler 2000; Butler and Campbell 2004; Cannon 2000; Daniels 2009; Garfinkel et al. 2010; Hames and Vickers 1982; Nagaoka 2002a, b, 2005; Ugan 2005a).

Individual hunters who are provisioning their households are expected to follow the prey-choice model as it ensures that resources will be obtained with relative efficiency. Such individuals should continue to capture high ranked prey on encounter even when population levels are low, but they are not expected to target these prey items to the exclusion of lower-ranked prey.

Costly signaling specifies a currency that differs from that used by the fine-grained prey choice model in that it is the cost, not the net energetic return rate, that is being used to evaluate whether a prey item should be targeted. In addition to the differences in currency, a signaling prey choice model assumes prey are not randomly encountered but purposely sought by hunters for their signaling value. Signaling hunters are expected to continue to target prey that have become rare on the landscape and ignore more abundant but lower ranked prey. By foregoing hunting of the lower ranked prey, they are incurring opportunity costs while increasing search costs for rare prey that have relatively high daily variance in success. Such hunters likely will have to fall back to the prey choice model after extended period of no success, but it is expected that "good" hunters will have to do so at a lower frequency as they are more capable of minimizing the opportunity and search costs through their greater capacity to target high signaling valued prey.

Similarly, prey species that are non-local and require extensive search and transport costs may be targeted by signalers. As previously discussed, Grimstead (2010) found that travel and transport costs are still low enough compared to the returns from artiodactyls that targeting non-local large game may still follow the prey choice model, but she did not incorporate a number of considerations into her model, such as the number of individuals present and the extended search times for large game. Not only might signaling hunters incorporate travel and transport costs, but they must also be familiar with more foreign landscapes that may impede the likelihood of success. Indeed, such wide knowledge of non-local environments may be an underlying trait of successful hunters valued by receivers of the signal.

In addition to rare and non-local taxa, other prey items may be sought by signaling hunters due to defense behaviors or method of capture. In addition to being comparatively rare in a given environment, large carnivores certainly pose certain dangers that only skilled hunters can avoid. Other taxa may preclude capture by inhabiting restricted landscapes. In western North America, mountain sheep frequent rugged mountain slopes that may be difficult for hunters to traverse. Pronghorn, the fastest herbivore in the world, occupy open plains that allow them to easily flee slower predators. Hunters must take advantage of their curiosity to outwit them, or alternatively, organize cooperative hunts. Such cooperative hunts may in fact incorporate high costs that exceed energetic returns. Lupo and Schmitt (2004) found that cooperative net hunting was relatively costly among Congo Basin Bofi, and corresponds with other patterns of signaling behavior. Ugan (2005b) also found that communal jackrabbit drives were exceedingly costly compared to individual hunts due to the large labor force required. It may be of note that such drives in the Great Basin were organized by “rabbit bosses”, one of the few leadership roles present among Numic-speaking societies (Steward 1933, 1938). As with Meriam turtle hunting, communal jackrabbit drives may be another case where context is significant as a single species may be captured for both signaling (communal) and non-signaling (individual) purposes.

Method of capture is thus also an important consideration as well, and temporal changes in hunting methods may alter the signaling value of a prey item. If technological innovations reduce hunting risks and costs for a particular species, the signaling value is expected to be reduced. In such a case, signaling hunters are expected to shift to other taxa that have maintained their signaling value. For example, the rapid adoption of the bow and arrow in North America may be a consequence of its higher overall efficiency. An ethnographic review of spear and bow and arrow weaponry found that spear hunting is generally limited to a smaller number of taxa, and mostly large game (Shott 1993). In contrast, bow hunting corresponds with a large suite of hunted species, most of which are smaller than those targeted by spear hunting. The use of spears for large game among ethnographic groups may be due to the higher return rates based on body size, but daily variance in success as well as search and handling costs were not considered. It may be that the continued use of spear hunting despite the introduction of the bow and arrow also represents costly signaling hunting behaviors.

This quality-dependent prey choice model predicts that the signal offered by a particular species will strengthen as acquisition costs increase. The consequence of these factors should be reflected archaeologically by the relative rarity of certain species in the faunal record, mirroring the fact that only some foragers would focus on acquiring the species necessary for costly signaling. It will be these species that are more frequently widely distributed between households, and will be driving the differences in richness and evenness between households.

For instance, resource depression caused by over-exploitation of a prey species could cause an increase in search time or travel distances to obtain the species. This would in turn lead to an increase in signaling value, potentially exacerbating the depression of the resource. However, the relative abundance of the species in the archaeological record may not initially reflect local abundances on the landscape if hunters chose to travel farther to acquire prey. It may not be until both the local and neighboring populations are depressed that the results are seen in the prehistoric record by decreased abundances. Such a shift may be present at Emeryville Shellmound, California, where Broughton (1994a) has shown that hunters began traveling further to hunt artiodactyls and transporting portions back to the village only after an initial decline in artiodactyl abundances from resource depression (see also Nagaoka 2001; Nagaoka 2005). The incurred transportation costs may have been greater than the cost of shifting to more local, lower-ranked resources, and would then reflect underlying signaling behaviors (I assume that prey are targeted as meat resources, and that other benefits, such as fur for clothing, are of secondary importance). As such, resource depression studies must analyze both relative species abundances and possible signatures for transportation concomitantly.

If costly signaling is driving some prey choice decisions, one has to wonder why many archaeological studies based on the traditional prey- and patch-choice model seem so successful in detecting resource depression (Bird and O'Connell 2006; Broughton 1994a, b; Butler 2000; Byers and Broughton 2004; Cannon 2001; Grayson 1991; Grayson and Cannon 1999; Lupo 2007; Lyman 2003; Nagaoka 2002a, 2005; Speth and Scott 1989; Ugan 2005a). There are three possible reasons for this. First, not all hunters are signaling, and those who are may still take prey on-encounter when they are unsuccessful in securing those species that can be used for signaling. Second, rarity and difficulty may relate to the size of the species, and since larger species have comparatively lower reproductive rates, fewer offspring, and larger ranges, there is likely a correlation between the actual currency (rarity, danger, etc.) and caloric returns (Brook and Bowman 2005; Broughton 1994a). Third, costly signaling may simply exacerbate the process of resource depression as individuals continue to pursue rare species to the point of their extirpation. Lastly, these factors are generally masked by the aggregated nature of the archaeological record, and resource depression is generally evaluated at a comparatively larger scale than spatially and temporally associated with individuals.

The third possibility may explain many modern threats to endangered species, and possibly even some megafaunal extinctions in the past (Haynes 2007; Winterhalder and Lu 1997). The importation of over 270 tons of "bushmeat", consisting primarily of small primates and rodents from Africa to Europe has been noted to be part of a luxury market (Chaber et al. 2010). Recent research has suggested that perceived rarity of animals increases their market value as exotic pets, hunting trophies, and luxury goods, creating a positive feedback in which endangered species become increasingly more endangered (Hall et al. 2008). Indeed, Hall and colleagues note many animal population characteristics that result in increased demand that are similar to the predictions made above for costly signaling hunting among prehistoric foragers. This includes species that are widespread but rare throughout their range (e.g., large carnivores), isolated to few locations (e.g., endemic species), locally scarce but common elsewhere, or are rarely encountered due to secretive behaviors or restricted habitats (Hall, et al. 2008). When species are listed under the Convention on International Trade in Endangered Species (CITES), increases in market demand have been observed, corresponding with higher costs by hunters, who often use the status of the species to inflate prices. Hall et al. also note that acquiring such species "may require such perceived attributes such as money, power, skill, and endurance" (Hall, et al. 2008)—in other words, these items are working as signals based on the relative costs of acquisition.

1.3 The Fremont: A Test Case

Two sets of predictions for identifying costly signaling forms of hunting have been identified: one that evaluates the distribution of faunal remains, and the second delimitating those species that should be targeted by signaling hunters. The general expectation is that as the value of some species changes through time as a result of shifting availability, the subsequent sharing of the captured meat from these animals should change from patterns representing reciprocity and scrounging behaviors to the widespread, indiscriminate sharing noted in some ethnographic cases. Applying these predictions requires archaeological materials selected on the basis of clearly identified household units with abundant faunal remains and identified changes in the relative faunal frequencies through time. Optimally, sites should represent relatively large population densities of people who would have had to depend on costly signaling behaviors to determine which individuals should be selected as mates and allies. A large economic dependence on foraging may also be important if signaling forms of hunting are representing some underlying trait in relation to foraging capacity, environmental knowledge, and similar characteristics.

The Fremont of the eastern Great Basin and northern Colorado Plateau provide a number of archaeological sites that fit these criteria. This culture occupied the region between ca. AD 400 and 1300 (Madsen 1989; Madsen and Simms 1998; Talbot and Wilde 1989). The archaeological traces of Fremont lifeways suggest considerable variability in their material culture and subsistence practices, resulting in an archaeological culture that is difficult to define by a single, cohesive set of traits shared by inhabitants of the region throughout this time period. Instead, the traits frequently associated with the Fremont, such as maize horticulture, basketry, and ceramics, appear in the region gradually. As such, the spatial and temporal boundaries for the Fremont are relatively fluid, blending into contemporaneous cultures of the Great Basin, the Plains, and the Anasazi. Understanding this variability has been one of the primary goals of Fremont archaeology, from migration-style interpretations made by culture historians to evolutionary ecology models for understanding differences in subsistence practices (Madsen 1979, 1980b; Madsen and Simms 1998).

There are, nonetheless, a number of traits that appear to unify most assemblages as a single Fremont culture group. It is the only culture group in the Great Basin with a ceramic tradition at this time, and differs from adjacent pottery-producing groups by thin-walled, coiled grayware that is generally undecorated (Janetski 1994). Fremont coiled basketry, characterized by one-rod-and-bundle and half-rod-and-bundle construction, was present throughout the region (Adovasio 1979, 1980, 1986, 1990, 2002). While some elements appear to have been borrowed from the Anasazi, such as false braid rims, it appears that the basketry tradition developed out of the preceding Archaic basketry technology. Other artifact types that appear to be limited to the Fremont Culture include hobnailed moccasins, Utah-style metates with deep troughs and platform, and distinctive rock art and figurines.

Above all, one of the most intriguing aspects of the Fremont period is the appearance of maize, bean, and squash horticulture in the region. There appears to have been considerable behavioral plasticity between farming and foraging, and explaining the spatial and temporal variability in maize horticulture has been one of the primary goals of Fremont archaeology. Madsen (Madsen 1979, 1989; Madsen and Lindsay 1977) maintains that wild resources played a more critical role in the eastern Great Basin than on the Colorado Plateau. Barlow (2006; Winterhalder and Kennett 2006) argues that partial reliance on horticulture may have assisted in reducing variance in daily returns from foraging, with an increase in farming during times when high-ranked resources were depressed. However, Grayson (in press) notes that few wild resources aside from large game provide higher net returns than corn. Furthermore, the regional climate change that allowed for maize horticulture would have increased the productivity of wild resources as well. Instead, it appears that maize horticulture was practiced whenever favorable environmental conditions were present. This follows Berry's (1980) argument that foraging was only important when maize horticulture provide low returns, the productivity of which has a spatial-temporal component through the Fremont region.

This variation in maize horticulture is not restricted to groups across time and space, as maize consumption appears to be uneven across individuals within populations. Dietary isotope data from burials recovered from the Great Salt Lake wetlands demonstrate that maize consumption corresponds largely with sex and prestige, with some males have greater maize intake than others (Coltrain and Leavitt 2002; Coltrain and Stafford 1999). Males from site 42WB324 had high maize intake, high nutritional stress, reduced robusticity, and more elaborate burial contexts, suggesting that they had comparatively higher status. Furthermore, individuals from villages tended to have higher values than burials from non-village contexts, and it may be that a selection of men from the wetlands controlled access to maize from village populations who were the primary farmers. Yet nitrogen isotope values do not differ between the sexes and site contexts, indicating that meat consumption was relatively equal among individuals.

Fremont residential bases consist of a variety of house structures, granaries, and activity areas that people were settling in one place for at least much of the year (Madsen 1980a). Pithouse villages may have been occupied during the winter as part of a biseasonal settlement system, although some sites have surface structures that may have been occupied during the summer as well (Talbot et al. 2000). House structures generally consist of semi-subterranean, circular to ovoid pithouses, although structures constructed from adobe and stone are present on the Plateau. The architecture is variable (Lohse 1980), but generally contain central fire pits, ventilator shafts, timber and adobe roofs, and adjacent storage units. Some sites have central structures that appear to have been built and used communally (Hockett 1998; Talbot and Janetski 2000).

There is a hierarchy of site/population size, from small, dispersed “rancheria” sites to very heavily aggregated village sites. Population growth appears to begin in the Fremont region as a whole around A.D. 900, with increased sedentism and general filling in of the resource rich, well-watered valleys of the Great Basin-Colorado Plateau Transition zone (Talbot 2000). While earlier residential sites are generally interpreted as having only about five contemporaneous household occupations at any given time, a number of larger village sites appear later in the chronology (Madsen and Simms 1998).

1.3.1 Five Finger Ridge

This research focuses specifically on the fauna at Five Finger Ridge, located in the Clear Creek Canyon, Utah (Janetski 1998; Janetski et al. 2000; Talbot, et al. 2000)(Figure 1.1). The site was excavated in 1984 as part of larger project mitigating the damages to a number of archaeological sites in Clear Creek Canyon by construction of Interstate 70 (Janetski, et al. 2000). The site sits on top of an alluvial knoll with a series of five ridges ranging from 1814 to 1829 m above sea level. Vegetation surrounding the site consists of scattered sagebrush, saltbrush, shadscale, grasses, prickly pear, squawbush, and other forbs and shrubs. The Clear Creek floodplain contained cottonwood, ash, sagebrush, willow, wildrose, wild grape, Mormon tea, rabbitbrush, grasses, and oakbrush.

1.3.2 Spatial Organization

Five Finger Ridge is the largest and most completely excavated Fremont site, making it an ideal location for testing the predictions for costly signaling hunting and sharing behaviors. At least 117 structures were identified at the site, eighty-one of which were excavated along with thirty-three activity areas (Figure 1.2). Structures consist of subterranean, subrectangular pit structures (n = 37), circular to oval subterranean secondary pit structures (n = 23), rectangular surface structures (n = 19), a single square surface structure, and a single jacal surface structure. Activity areas consist of use surfaces (n = 21), borrow areas (n = 7), and open features (n = 6).

Each of the site contexts was assigned to one or more temporal period based primarily on radiocarbon dates with support coming from dendrochronology, archaeomagnetic dates, and obsidian hydration, as well as association with other, more securely-dated contexts (primarily other structures). Dates older than A.D. 1200 are assigned to Period 1, between A.D. 1200-1300 to Period 2, and younger than A.D. 1300 to Period 3. Five Finger Ridge was most intensively occupied during Period 2, which is divided further into two parts: Period 2A (A.D. 1200-1250) and Period 2B (A.D. 1251-1300). To simplify comparisons, I use the period designations proposed by Talbot et al. (2000) based on “index dates” (Table 1.2a-c). These dates were formed using the calibrated age (curve intercept) of the most recent date from a feature, while considering the age in relation to other dated contexts (Talbot et al. 1998). These should not be interpreted as a precise date, but instead can be used to sort features through time. In some cases, the authors provided multiple period designations for single contexts (e.g., one period is provided based on index date, but additional questionable periods are based on location and relationship with other dated contexts). Three pithouses are clearly associated with Period 1, and an additional seven pithouses may also date to this period based on early dates and other evidence. Eight pithouses are securely placed in Period 2a, and thirteen additional household structures may also be placed into this period. Seventeen structures may have been occupied simultaneously in Period 2b, with 11 other pithouses less securely placed into this period.

I will use the temporal period designations to identify diachronic changes in the distribution of fauna among households. The more precise index dates are not available for all structures. Furthermore, these incorporate a greater degree of uncertainty, including both bridging arguments between the dated event and target event, as well as the error terms inherent within the radiocarbon dates, both of which can be minimized by using larger temporal units. Since Five Finger Ridge was occupied for a relatively narrow period of time, it is expected that any changes in resource abundances will be linear, allowing one to identify patterned spatial and resource abundance differences between the earliest and latest occupations.

Fremont sites were probably occupied for only a few generations, and it is estimated that individual pithouse use-life ranged from ten to 25 years (Cameron 1990; Gilman 1987; Janetski, et al. 2000; Jennings 1978; Sharp 1992). Structures appear to have been occupied for enough time to identify the cumulative effects of sharing between households while being temporally limited enough to minimize the impact of individual life history changes. Talbot and Janetski (2000) evaluated the distribution of bone located on selected pithouse and activity area floors and lower fill to determine whether large bone debris recovered from the floor represented activities immediately prior to abandonment or are simply the earliest portion of the structure fill. The distribution of bone differ between the floor and lower fill contexts, indicating that they were deposited as separate events. There is, however, variability in the quantity of bone on structure floors, possibly representing differences in floor maintenance or seasonality of abandonment. It was also discovered that bone debris is much more common on pithouse floors compared to storage and secondary structure floors, supporting that latter were not used for food consumption (Talbot et al., 2000).

These researchers also used the distribution of artifact clusters among four quadrants to evaluate the use of space within the structures. Food preparation and cooking generally occurred in the front quarter of the pithouse and the area surrounding the central hearth, while stone tool manufacturing tends to be concentrated towards the back of the house. Grinding activities occurred in both the “Right” and “Left” quadrants. The division of space corresponds with microrefuse analysis conducted by Metcalfe and Heath (1990) at Heartbreak Hotel at Nawthis Village, a Fremont site in central Utah.

There appears to be differences among house structures at Five Finger Ridge that may correspond with individual leaders or communal spaces. Pithouse 57 area measures 31.6 m^2, much greater than the second largest structure (Pithouse 3 = 22.1 m^2) and over twice the size of the mean pithouse size (12.9 m^2). It is also centrally located within the site, and is unusual in that it contains two hearths. Considering the size, construction, and location within the site, Talbot et al. (2000) believe it may be associated with village leaders.

Talbot and his colleagues also argue for the presence of a central structure (Central Structure 24), a jacal construction that is larger than all other structures aside from Pithouse 57. It is also centrally located, and it is argued on the basis of the lack of storage or seed grinding equipment within the structure that it is a communal structure and not used for domestic activities (Talbot et al. 2000). Hockett's (1998) analysis of the spatial distribution of faunal remains at Baker Village found that the central structure at this site had a larger quantity of artiodactyl and leporid bones compared to the adjacent pithouses, possibly representing feasting. Central Structure 24 differs from the Baker Village example in that faunal remains and other artifacts differ little from the content in pithouses.

Since the faunal remains on pithouse floors represent a limited number of foraging and sharing episodes, this dataset should not be influenced by individual life history changes. In addition to occupational surfaces, comparisons can also be made between fill and refuse piles if it is assumed that these represent cumulative deposits of a larger number of events from a single household. Furthermore, while chronometric data are not refined enough to ensure contemporaneity between houses, the goal of this research is not to detect specific sharing events and networks but to identify the general signatures in households within a relatively narrow time period immediately prior to abandonment of the structure. The sharing patterns should be identifiable regardless of when the house was abandoned in relation to other structures, as the predictions for each household are independent of all others.

1.3.3 Climate Change and Resource Fluctuations

In order to identify changing signal value of animal resources, I must be able to identify shifts in their local abundances. It is predicted that species that become increasing more rare on the landscape will have increasing signal value, and the sharing of meat from such animals will subsequently change. Whether reduction in game populations resulted from climate change or overhunting is unimportant here, as it is simply the changing rarity that would have been of value to signaling hunters. My focus is not to document the impact of climate or over-hunting on artiodactyl abundances based on an energy-based prey choice model, but to determine whether changes in resource availability influences signaling behaviors. Previous research at Five Finger Ridge and the Fremont in general support that game animals altered in abundance through time, and may be related to either climate or overhunting (e.g., Janetski 1996; Sharp 1992; Ugan 2005a).

The Fremont as a whole occupied the eastern Great Basin during a period of increased summer temperatures and summer moisture (Grayson 2006a; Rhode 2000; Wigand and Rhode 2002), and warm and wet winters. This allowed for maize cultivation in the region, as well as greater grass abundance that supported bison populations that moved into the Great Basin from adjacent regions (Grayson 2006a). Just as the appearance of the culture complex as a whole corresponds with increased summer precipitation, the Fremont, bison, and maize disappear when monsoonal storm patterns weaken around AD 1300 (Grayson 2006a; Janetski 1994; Madsen and Simms 1998).

Pollen sequences obtained from Sheep Shelter and Cave of 100 Hands during the Clear Creek Canyon project provide local paleoenvironmental data for Five Finger Ridge

(Newman 2000). These datasets largely corroborate climate data obtained elsewhere in the eastern Great Basin and northern Colorado Plateau during Fremont times. At Sheep Shelter, the period between ca. AD 500-1150 is characterized by warm and moist conditions, with pine dominating juniper, as well as sedges and cattails over Cheno-Ams. There appears to be an influx of winter precipitation around AD 1000, as seen by a spike in the sagebrush to grass ratio. Afterwards, there is a gradual change in paleoenvironment beginning around AD 1150, with juniper dominating over pine, grass over sagebrush, and Cheno-Ams over sedge and cattail. This shift towards more open vegetation continues until AD 1550, and likely represents a climatic shift from a summer monsoonal pattern towards greater winter precipitation. The pollen data from Cave of 100 Hands shows similar patterns through time (Figure 1.3).

Previous studies have established that changes in resource availability occurred in the Fremont region. Janetski (see also 1997; Sharp 1992) established that artiodactyl abundances decreased through time when compared with lagomorphs, and used the prey choice model to argue that this resulted from over-hunting corresponding to increased sedentism. However, his analysis covered the entire Fremont region, and individual faunal assemblages may have been impacted by non-anthropogenic environmental variation instead, including geography (e.g., elevation, latitude) and local climate (Broughton 1994a; Hockett 2005; Ugan 2005a). Ugan (2005a) restricted his analysis to the Parowan Valley region and compared changes in artiodactyl abundances through time with local tree-ring records and bone attrition. His data suggest that artiodactyl abundances changed due to climate rather than human predation, with arid conditions resulting in more lagomorphs as well as more intense processing of artiodactyl bones, possibly for grease extraction.

Climatic change combined with increased human hunting pressure on local resources associated with intensified site use could likewise result in changing use of faunal resources at Five Finger Ridge. Talbot et al. (2000) analyzed taxonomic richness across time, but found that sample size explains the differences between temporal periods. When evaluating the composition of taxa among structure through time, they found an increase in the number of cottontail rabbits and corresponding decrease in artiodactyls during Period 2B. This increase may have been the result of overhunting larger game, climate change, or differing use of local resources (e.g., garden hunting). No matter what the cause, the decrease in artiodactyls may have increased their signaling value, and it is expected that the distribution of their remains will change through the Five Finger Ridge sequence.

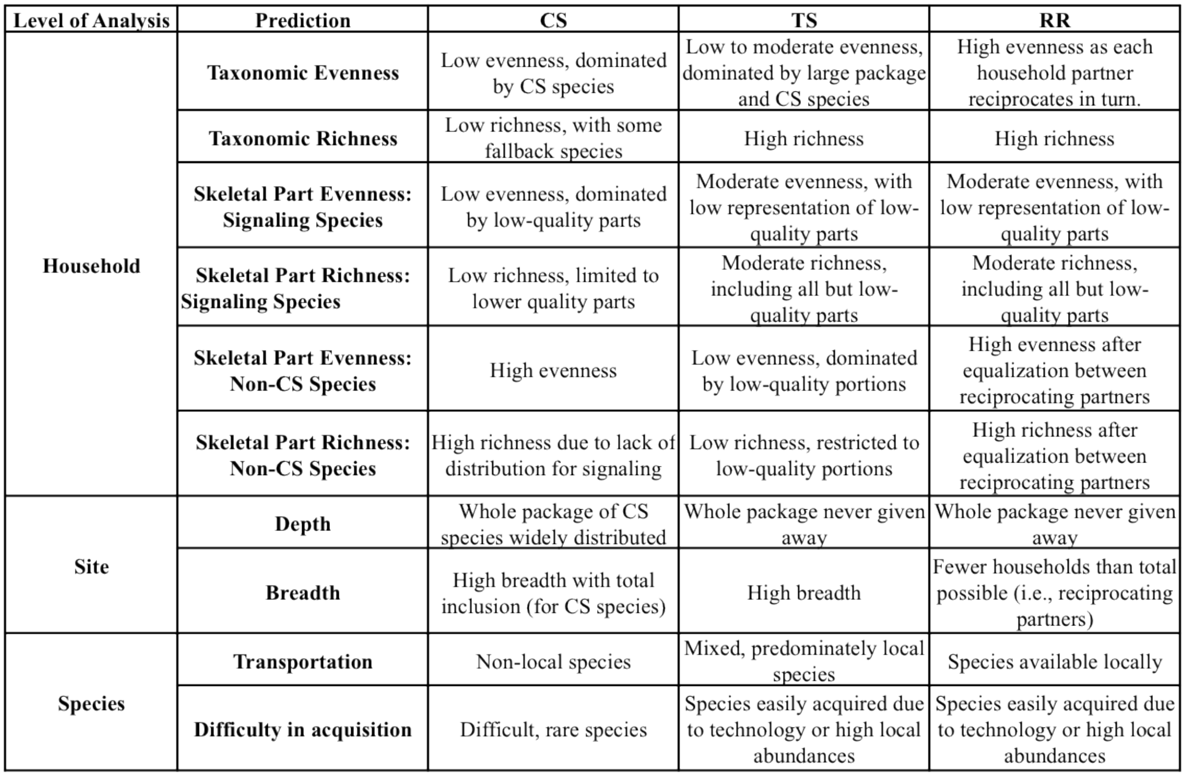
1.4 Volume Structure

In order to identify costly-signaling in the archaeological record, I have argued that it will be necessary to construct a prey-choice model while considering changing resource abundances and transportation costs. Additionally, it will be necessary to infer sharing archaeologically to test whether specific prey were distributed widely for signaling purposes. Costly signaling will be identified by the distribution of faunal remains among households, and by the changes in this distribution that correspond with shifting signal values of particular species. By taking this temporal approach, equifinality between sharing patterns and site formation processes (e.g., discard behaviors) will be avoided, as it is assumed that site formation processes are constant through time.

In the following chapters, I will first present the results of my analysis of the mammalian fauna. This will be followed by a discussion of the taphonomic history of the fauna in Chapter 3, a critical step that must be taken in order to filter out post-deposition effects in an effort to identify taxonomic and skeletal part distributions that may be related to costly signaling and other behaviors. After considering the limitations of the data that result from non-cultural processes, the exploitation of mammalian resources will be outlined in Chapter 4 in light of climate data. Chapter 5 will introduce the use of heavy and light isotopes as a method for identifying changes in resource acquisition that may not be identified using more traditional zooarchaeological procedures due to taphonomic and behavioral issues. The results of the above will then be synthesized and evaluated in relation to costly signaling theory and the derived expectations for the archaeological record presented in this chapter.

Tables

Table 1.1. Archaeological predictions for Costly Signaling (CS), Tolerated Scrounging (TS), and Risk Reduction Reciprocity (RR).

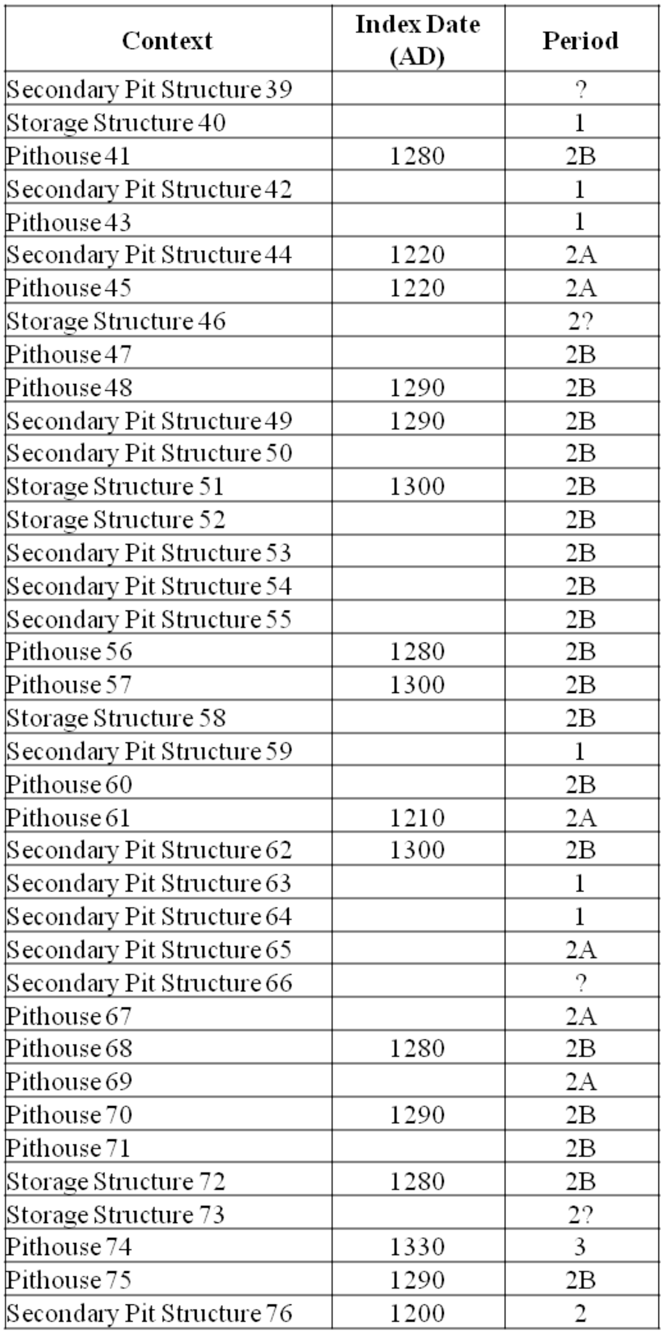


Level of Analysis	Prediction	CS	TS	RR
Household	**Taxonomic Evenness**	Low evenness, dominated by CS species	Low to moderate evenness, dominated by large package and CS species	High evenness as each household partner reciprocates in turn.
	Taxonomic Richness	Low richness, with some fallback species	High richness	High richness
	Skeletal Part Evenness: Signaling Species	Low evenness, dominated by low-quality parts	Moderate evenness, with low representation of low-quality parts	Moderate evenness, with low representation of low-quality parts
	Skeletal Part Richness: Signaling Species	Low richness, limited to lower quality parts	Moderate richness, including all but low-quality parts	Moderate richness, including all but low-quality parts
	Skeletal Part Evenness: Non-CS Species	High evenness	Low evenness, dominated by low-quality portions	High evenness after equalization between reciprocating partners
	Skeletal Part Richness: Non-CS Species	High richness due to lack of distribution for signaling	Low richness, restricted to low-quality portions	High richness after equalization between reciprocating partners
Site	**Depth**	Whole package of CS species widely distributed	Whole package never given away	Whole package never given away
	Breadth	High breadth with total inclusion (for CS species)	High breadth	Fewer households than total possible (i.e., reciprocating partners)
Species	**Transportation**	Non-local species	Mixed, predominately local species	Species available locally
	Difficulty in acquisition	Difficult, rare species	Species easily acquired due to technology or high local abundances	Species easily acquired due to technology or high local abundances

Table 1.2a. Structure and Activity Area designations, index dates, and period of use. Data from Talbot et al. (2000: 215-17)

Context	Index Date (AD)	Period
Storage Structure 1	1290	2B
Pithouse 2	1290	2B
Pithouse 3	1300	2B
Storage Structure 4	1300	2B
Pithouse 5	1220	2A
Storage Structure 6	1220	2A
Pithouse 7	1220	2A
Storage Strucure 8		1
Pithouse 9		1
Secondary Pit Structure 10		2?
Pithouse 11	1250	2A
Secondary Pit Structure 12		1
Pithouse 13	1100	1
Pithouse 14	1250	2A
Pithouse 15	1280	2B
Secondary Pit Structure 16	1280	2B
Pithouse 17	1280	2B
Storage Structure 18		1
Secondary Pit Structure 19		?
Pithouse 20	1220	2A
Secondary Pit Structure 21		1
Pithouse 22		1
Storage Structure 23		1
Central Surface Structure 24	1220	2A
Surface Structure 25	1350	3
Pithouse 26		1
Storage Structure 27		1
Pithouse 28	1110	1
Pithouse 29	1110	1
Pithouse 30		1
Storage Structure 31		?
Secondary Pit Structure 32	1280	2B
Pithouse 33	1350	3
Storage Structure 34		2?
Secondary Pit Structure 35		2?
Pithouse 36	1230	2A
Storage Structure 37	1230	2A

Table 1.2b. Structure and Activity Area designations, index dates, and period of use, continued.



Context	Index Date (AD)	Period
Secondary Pit Structure 39		?
Storage Structure 40		1
Pithouse 41	1280	2B
Secondary Pit Structure 42		1
Pithouse 43		1
Secondary Pit Structure 44	1220	2A
Pithouse 45	1220	2A
Storage Structure 46		2?
Pithouse 47		2B
Pithouse 48	1290	2B
Secondary Pit Structure 49	1290	2B
Secondary Pit Structure 50		2B
Storage Structure 51	1300	2B
Storage Structure 52		2B
Secondary Pit Structure 53		2B
Secondary Pit Structure 54		2B
Secondary Pit Structure 55		2B
Pithouse 56	1280	2B
Pithouse 57	1300	2B
Storage Structure 58		2B
Secondary Pit Structure 59		1
Pithouse 60		2B
Pithouse 61	1210	2A
Secondary Pit Structure 62	1300	2B
Secondary Pit Structure 63		1
Secondary Pit Structure 64		1
Secondary Pit Structure 65		2A
Secondary Pit Structure 66		?
Pithouse 67		2A
Pithouse 68	1280	2B
Pithouse 69		2A
Pithouse 70	1290	2B
Pithouse 71		2B
Storage Structure 72	1280	2B
Storage Structure 73		2?
Pithouse 74	1330	3
Pithouse 75	1290	2B
Secondary Pit Structure 76	1200	2

Table 1.2c. Structure and Activity Area designations, index dates, and period of use, continued.

Context	Index Date (AD)	Period
Secondary Pit Structure 77		1
Storage Structure 78		2?
Pithouse 79	1230	2A
Storage Structure 80	1230	2A
Pithouse 81	1230	2A
Activity Area 1		2A
Activity Area 2		?
Activity Area 3		?
Activity Area 4		?
Activity Area 5		2B
Activity Area 6		?
Activity Area 7		?
Activity Area 8		1
Activity Area 9		1
Activity Area 10		1
Activity Area 11	1230	2A
Activity Area 12		?
Activity Area 13		?
Activity Area 14		?
Activity Area 15		?
Activity Area 16		2A
Activity Area 17		?
Activity Area 18	1290	2B
Activity Area 19		2B
Activity Area 20		2B
Activity Area 21		2A
Activity Area 22		2?
Activity Area 23		?
Activity Area 24		2A
Activity Area 25		2A
Activity Area 26		?
Activity Area 27		?
Activity Area 28		2B
Activity Area 29		2B
Activity Area 30		?
Activity Area 31		?
Activity Area 32		2B
Activity Area 33		2B

Figures

Figure 1.1. Location of Five Finger Ridge in Clear Creek Canyon, Utah.

Figure 1.2. Five Finger Ridge site plan.

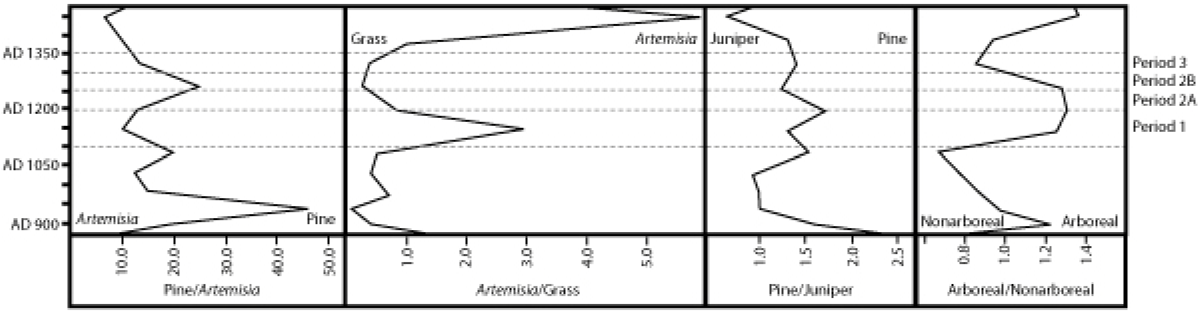


Figure 1.3. Pollen ratios for Cave of 100 Hands. Figure modified from Newman (2000).

Chapter 2

DESCRIPTIVE SUMMARY OF THE FIVE FINGER RIDGE MAMMALIAN FAUNA

2.1 Introduction

The mammalian fauna from Five Finger Ridge was initially analyzed by Michael J. Hall of Brigham Young University. As will be seen, my reanalysis of the Five Finger Ridge mammals provided results that are in some cases distinctly different from those provided by Hall (Talbot et al. 2000). In this chapter, my focus is on presenting new data on the taxonomic composition of the mammalian fauna, as well as data on surface modifications that may be indicative of resource use. This chapter, alongside the following chapter that will discuss the taphonomic impacts on the assemblage in depth, will provide the framework for identifying patterns in the Five Finger Ridge assemblage that may be indicative of the interactions between human behavior and the biotic landscape.

2.2 Taxonomic Summary

My analysis was conducted using comparative collections available at the Burke Museum of Natural History and Culture, as well as a number of reference texts (Barone and Bortolami 1996; Elbroch 2006; Glass and Thies 1997; Jones and Manning 1992), supplemented by various published references for artiodactyls (e.g., Ford 1990; Gilbert 1980; Hildebrand 1955; Lawrence 1951), *Sylvilagus* spp. (Dalquest et al. 1989), *Thomomys* sp.

(Thaeler 1980), *Neotoma* spp. (Grayson 1988), and various Sciuridae (Sharp 1992). Thomas' (1969) classification for body size was used to categorize unidentified specimens. No attempt was made to identify postcranial microfaunal (Class 1) remains (e.g., small rodents, such as voles, pocket mice, and deer mice, that weigh less than 100 g). Specimens were recorded according to taxonomic designation, element and portion, side, and a variety of cultural and natural taphonomic modifications.

The complete inventory of the taxa identified at Five Finger Ridge and their NISP values are presented in Table 2.1, alongside the NISP counts from the earlier analysis presented in the original report (Talbot, et al. 2000). The distribution of taxa across specific site contexts can be found in Appendix A. Differences in counts between the two analyses will be discussed in detail in Section 2.2.2. Unless otherwise noted, all taxa are found locally and discussions below are limited to only those taxa that require clarification of the criteria used to make the identification or were not discussed in the original report. Details regarding modern distributions of previously identified taxa can be found in the site report (Talbot, et al. 2000) and references therein (e.g., Durrant 1952; Sharp 1992).

Sylvilagus spp. (Cottontail Rabbits)

The most dominant taxon in the assemblage is *Sylvilagus* (cottontail rabbits). I identified two species of *Sylvilagus* in the Five Finger Ridge assemblage based on the degree of crenulation of the occlusal surface of the third premolar (Dalquest, et al. 1989; Sharp 1992). The degree of crenulation was categorized into one of seven classes ranging from no crenulation to strong crenulation. The distribution of specimens among these classes demonstrate that teeth with relatively simple (*S. nuttallii*) and strong (*S. audubonii*) crenulation are nearly equally represented in the assemblage (Figure 1). It should be noted that no specimens of *Brachylagus idahoensis* were identified based on the occlusal morphology of PM^3 (Jones and Manning 1992).

Both species of cottontail presently occur in central Utah, but occupy different ecological zones (Hall 1981). *S. nuttallii* (Nuttall's or mountain cottontail) generally occupies wooded or brushy areas in the Upper Sonoran lifezone. Chapman lists the elevation limit between 1372 m and 3200 m (Chapman 1975), but Hall notes a specimen from 1189 m in the Pine Forest Range of Nevada (Hall 1946). *S. audubonii* (desert cottontail) is present in dense, brushy areas of desertscrub and plains-desert grasslands of the Lower Sonoran lifezone at elevations from sea level to 1829 m (Chapman and Willner 1978; Hall 1946; Hoffmeister 1986). Presently, the range limit for *S. audubonii* is immediately to the west of Clear Creek Canyon, along the western edge of the Pahvant Range. The elevation of the site (1814-1829 m above sea level) is at the modern extent of *S. audubonii*. When the two species are found in the same region, *S. audubonii* always lives at the lower desert valleys while *S. nuttallii* inhabits higher, rocky, sage-dominated areas (Chapman 1975; Hall 1946).

Ammospermophilus leucurus (White-tailed Antelope Squirrel)

Cranial morphology and the location of the masseteric tubercle may be used to distinguish *A. leucurus* from other ground squirrels (Sharp 1992). Three specimens comprising a nearly complete cranium and mandible of a single individual were identified in the fill of Structure 23 based on these criteria and on dental morphology. *A. leucurus* is present through much of Utah, occupying desert floors and into the juniper belt (Belk and Smith 1991; Durrant 1952).

Spermophilus variegatus (Rock Squirrel)

Spermophilus variegatus is the most abundant sciurid present in the Five Finger Ridge assemblage. I identified cranial specimens to *S. variegatus* based on morphology and dentition. Post-cranial identifications are based on the relatively large size of rock squirrel skeletal elements compared to other ground squirrels; the rock squirrel is the largest ground squirrel present in the region, easily distinguished from the smaller sciurid species and the larger *Marmota* and *Cynomys* species. Sharp (1992) provides alveolar lengths for modern specimens of *S. townsendii*, *S. armatus*, and *S. variegatus* to demonstrate the relative size differences across the three species. Twelve mandibular specimens identified to *S. variegatus* from Five Finger Ridge had complete alveolar sections; the measurements are provided in Table 2.2. While generally in the range of Sharp's measurements, the Five Finger Ridge samples are statistically larger on average ($t = 2.87$, $df = 40$, $p = .007$). This difference may represent a real difference in size between the modern and prehistoric populations, or alternatively, may be the result of differences in how the alveolar length was measured.

Durrant (1952) notes that *S. variegatus* inhabits foothills in Salt Lake County at elevations of approximately 1375 to 2745 m above sea level, although its altitudinal distribution is likely related to latitude (Oaks et al. 1987). Hoffmeister (1986) reports specimens from 488 m above sea level in Yuma County, Arizona

The species ranges through Mexico and the American Southwest, but extends northward through the central ranges of Utah (Durrant 1952). Clear Creek Canyon is located close to its western boundary. As its name suggests, it prefers rocky habitats and is generally absent in the desert, valleys, and high montane forests (Oaks, et al. 1987).

Thomomys bottae (Botta's Pocket Gopher)

Two species of *Thomomys* are present in Utah: *T. bottae* (southern pocket gopher) and *T. talpoides* (northern pocket gopher). I was able to identify mandibular specimens to species based on the presence of a rounded anterior prism of P_4 on the mandible (the shape of which is retained in the empty alveolus on edentulous specimens), or the posterior position of the incisive foramina relative to the infraorbital foramen of the maxilla (Hoffmeister 1986; Thaeler 1980). Using these criteria, 311 mandibles and 83 anterior cranial specimens were identified as *T. bottae*; no specimens of *T. talpoides* are present in the assemblage. While *T. bottae* is generally larger than *T. talpoides*, previous research has shown that there is significant overlap in size between the two species (Grayson 1988; Sharp 1992).

Although the range of *T. talpoides* extends southward into central Utah, it is currently restricted to the higher elevation montane areas of the central ranges at elevations ranging from 2100 to 2900 m above sea level (Durrant 1952; Sharp 1992). The absence of specimens from Five Finger Ridge indicates that the northern pocket gopher was limited to higher elevations throughout the occupation of the site.

Dipodomys spp. (Kangaroo Rats)

According to Durrant (1952), two species of *Dipodomys* are present in the vicinity of Five Finger Ridge, *D. ordii* (Ord's kangaroo rat) and *D. microps* (chisel-toothed kangaroo rat). I identified cranial and mandibular specimens using the morphology of the zygomatic arch, the rostrum, the interparietal, and the lower incisor (Grayson 2000b; Hall 1946). The chisel-tooted kangaroo rat is highly adapted to shadscale communities, while Ord's kangaroo rat tends to occupy sagebrush habitats (Hoffmeister 1986).

Perognathus sp. (Pocket Mouse)

I used the morphology of the masseteric ridge, the coronoid and condyloid processes, and the diastema to distinguish *Perognathus* specimens from *Dipodomys* spp. One species of pocket mouse, *P. parvus* (Great Basin pocket mouse), is currently found in western Utah. Durrant (1952) limits the range to the area of Pleistocene Lake Bonneville to the west of Five Finger Ridge, but Verts and Kirkland (1988) extend the range east beyond Sevier Valley. The species occupies arid and semiarid habitats dominated by sagebrush (Verts and Kirkland 1988).

Castor canadensis (American Beaver) and Erethizon dorsatum (Common Porcupine)

The bones and teeth of beaver and porcupine are readily distinguishable. Postcranial skeletons differ greatly in morphology, robusticity, and dimensions. The dentition, while roughly similar in outline, differs drastically in occusal surface morphology and in other ways as well. Virtually all parts of the skeleton are easily identified.

I mention this because the numbers of the two species that I report here differ substantially from those reported in the original report (Talbot, et al. 2000: Appendix G). For example, M. Hall identified seven *Castor* and one *Erethizon* mandibles, compared to two *Castor* and six *Erethizon* mandibles in the present analysis; the decrease in *Castor* and increase in *Erethizon* is certainly due to misidentifications in the previous analysis (see Section 2.3).

Peromyscus sp. (Deer Mice)

All cricetine mandibular specimens are edentulous, limiting the level of identification to genus. *Peromyscus* mandibles may be distinguished from *Onychomys* and *Reithrodontomys* by the position and shape of the masseteric ridge, the coronoid process, and ascending ramus. In *Peromyscus*, the anterior end of the masseteric ridge is comparatively slender, ending beneath or posterior to the anterior root of the first lower molar. In *Reithrodontomys*, the masseteric ridge curves upward to the anterior root of the first lower molar, and has a relatively short and broad diastema with a large mandibular foramen. The coronoid process is relatively short in *Reithrodontomys* and *Peromyscus* compared to *Onychomys*. Lastly, the ascending ramus sweeps upwards at the posterior end of the alveolus for the last molar in *Onychomys*, and more anterior at the second lower molar in *Reithrodontomys* and *Peromyscus*. As a result, when the mandible is viewed buccally, the last lower molar is not visible in the latter two species.

Using these criteria, I identified all cricetine rodents as *Peromyscus*. Four species representing this genus are present in central Utah today: *P. maniculatus* (deer mouse), *P.*

crinitus (canyon mouse), *P. truei* (pinyon mouse), and *P. boylii* (brush mouse) (Durrant 1952; Sharp 1992).

Neotoma lepida (Desert Woodrat) and N. cinerea (Bushy-tailed Woodrat)

I identified two species of *Neotoma* at Five Finger Ridge using alveolar and tooth length and general size of post-cranial specimens; *N. lepida* tends to be smaller than *N. cinerea*. The morphology of the upper first molar may be used to distinguish the two species using the depth of the reentrant angle of the anterior prism (deep in *N. cinerea*, shallow in *N. lepida*). All specimens with M1 are *N. cinerea* based on this criterion.

Using modern samples of the two species, Grayson (1988, 2000a) found that mandibular and maxillary alveolar lengths could be used to distinguish the two species in edentulous specimens, although caution must be exercised in extending this to occlusal lengths as tooth wear results in a higher degree of overlap between the two species. Alveolar lengths for edentulous maxillae and occlusal lengths for maxillary molars are presented in Table 2.3, and the same measurements for mandibular specimens are presented in Table 2.4.

N. cinerea are unable to tolerate high ambient temperatures; as such, it is the most boreal species of the genus, occupying Boreal and Transition life zones at elevations from approximately 1525 m to 3000 m above sea level (Durrant 1952; Hall 1946; Sharp 1992; Smith 1997). *N. lepida* prefers desert habitats, occupying Lower and Upper Sonoran life-zones up into the juniper zone (Hall 1946; Verts and Carraway 2002).

Microtus longicaudus (Long-Tailed Vole)

M. montanus and *M. longicaudus* are both present today through most of Utah (Durrant 1952). A third species of vole present in central Utah, *Arvicola richardsoni* (water vole), is much larger than these two *Microtus* species and is limited to the alpine and subalpine riparian zones of the Uinta and Wasatch mountains (Durrant 1952; Ludwig 1984). *M. montanus* were distinguished from *M. longicaudus* using criteria presented by Maser and Storm (1970). The montane vole has incisors that protrude beyond the nasal bones when viewed dorsally, have incisive foramina that taper towards the posterior end, and generally have a ridge between the orbits. In the long-tailed vole, the incisors do not extend beyond the nasal bones, the incisive foramina do not taper, and the ridge between the orbits is seldom present. Using these criteria, all cranial elements were identified as *M. longicaudus.*

Canis sp. (Dogs, Coyotes, and Wolves)

Dog (*Canis lupus familiaris*) and the similar sized coyote (*C. latrans*) may be distinguished based on the crowding of dentition and relative curvature of long bones in domesticated dogs. The relative crowding of dentition is the result of ontological reduction in the length of the snout in domestic dogs, and can be recorded metrically using the ratio of the palatal width at the inner margins of the first premolars divided by the length between the anterior margin of the first premolar to the posterior margin of the last molar (Howard 1949). *C. latrans* is characterized by a ratio of greater than 3.1, representing a narrow rostrum, while *C. l. familiaris* has a ratio of less than 2.7.

Two maxillary specimens of *Canis* are nearly complete, with only the posterior margin of the last molar missing in both specimens. Measurements for the two specimens are presented in Table 2.5. Specimen 8261-033 is clearly within the range of *C. latrans*, while the ratio of the second specimen (10236-022) indicates that it most likely represents *C. l. familiaris*.

Two tibiae (10279-124, 9937-001) and one humerus (9087-001) had sufficient portions of the shaft to identify them as *C. latrans*; all three specimens have relatively straight shafts that compare best with coyote. An additional tibia specimen (8111-002) represents an extremely young individual based on the level of porosity and lack of development of cortical bone structure. However, while comparing well with the general morphology of adult *C. latrans*, it is too large considering the age of the individual. Wolves (*C. lupus*) were once widespread in Utah (Durrant 1952), and it is possible that this single specimen represents a wolf pup. Unfortunately, comparative materials of young wolves were not available. Interestingly, this specimen also exhibits a prominent mark consistent with chopping at the proximal end.

***Spilogale gracilis* (Western Spotted Skunk)**

A single maxillary fragment of *S. gracilis* was identified based on dentition and general morphology. The western spotted skunk is currently found throughout Utah (Durrant 1952), generally occupying rocky area in the vicinity of riparian zones (Verts et al. 2001).

Lynx canadensis (Lynx) and Lynx rufus (Bobcat)

These two species of felids were distinguishable based on relative size, with *L. canadensis* being significantly larger than *L. rufus*. The single specimen of *L. canadensis* (10224-001) is an innominate that falls out of the size range of *L. rufus* comparative materials. The earlier analysis reported in Talbot et al. (2000) notes only the presence of *L. rufus*.

Two *L. rufus* ulna specimens (9293-001 and 10281-003) appear to be a matching bilateral pair from a single individual based on similar morphology and size. Both exhibit long cutmarks parallel to the shaft along its entire length, possibly relating to skinning activities. These were recovered from two separate contexts (Pithouse 56 floor and Secondary Pit Structure 65 fill). The presence of carnivore gnaw marks on only one specimen (10281-003) suggests that it may have been carried away from its original context (the floor of Pithouse 56) and deposited by a scavenger in the fill of structure 65.

Odocoileus hemionus, neonatal specimens

Neonatal (late fetal or newborn) specimens are a common occurrence in the Five Finger Ridge assemblage. Comparative specimens of newborn *Odocoileus virginianus*, *Ovis aries*, and *Antilocapra americana* were used to identify dentition to species; no attempt was made to identify postcranial neonatal artiodactyl specimens due to the level of development and the high rate of attrition resulting from the undeveloped bone. The *Odocoileus* comparative exhibited sharper lingual crests with accessory cusps on pm_4 compared to the relatively simple, rounded crests of *Ovis* and *Antilocapra*. The lingual-buccal width of the lower, unworn premolars also differs between the three species, with the greatest depth in *Odocoileus* neonatal dentition in general. In comparison, the lower premolar width of *Ovis* is moderately narrow and *Antilocapra* is very narrow, as is the case in older individuals. For the upper, unworn premolars, *Odocoileus* is readily distinguished by relatively complex occlusal surfaces.

In all three comparative specimens, the lower premolars have erupted and M_1 is in formation. This differs from the observations made by Robinette and colleagues (1957) for tooth eruption sequences in *Odocoileus hemionus*, who list individuals under two weeks old as having only partially erupted dentition, and it is suspected that they defined eruption based on the emergence of the tooth through the gumline and not the alveolus.

Using these criteria, all endentualous neonatal mandibular specimens were identified as *Odocoileus*. However, there is at least one very young *Ovis* individual based on the presence of unworn DPM^{2-4} specimens (10279-079a-c), as well as one young *Antilocapra* individual represented by a single mandible fragment that has little or no wear on the deciduous DPM_2 (8169-001). Both specimens have bone that is much more structurally dense than the specimens identified as *Odocoileus* and the comparative samples, and likely represent slightly older individuals. Although caution must be exercised in assigning the Five Finger Ridge artiodactyl neonatal postcranial specimens to *Odocoileus*, the bulk of the neonatal artiodactyl postcranial specimens must certainly represent deer.

Antilocapra americana (Pronghorn)

Pronghorn was not previously identified at Five Finger Ridge. It is the rarest of the three medium-bodied artiodactyls, represented primarily by skeletal parts comprising the lower hindlimb and foot (NISP = 30, total NISP = 40). The hindlimb specimens most frequently consist of the distal tibia, astragalus, and fibular malleolus. Four sets of articulating distal hindlimb elements were also recovered. At least three individual pronghorn are present at Five Finger Ridge based on the distal right tibiae and right fibular malleolus.

Antilocapra inhabits grasslands and grassland-brushlands (O'Gara 1978), and would not likely have been acquired within Clear Creek Canyon. These probably represent individuals acquired from the nearest lower elevation valleys. Sevier Valley is approximately 4.25 km to the east, and it may be of note that pronghorn were not historically present in here, although populations may have been extirpated since the period of European settlement (Durrant 1952; Yoakum 2004). Sharp (1992) reports sixty-three specimens from Nawthis Village, located on the northern edge of Fishlake Plateau to the east of Sevier Valley, over 65 km to the northeast of Five Finger Ridge. No specimens were recovered from Backhoe Village, located within Sevier Valley approximately 40 km north of the confluence of Clear Creek and Sevier River (Madsen and Lindsay 1977).

2.2.2 Comparisons with Previous Analyses

Taxonomic frequencies for the current analysis are tabulated against the results of the previous analysis conducted by Hall in Table 2.6. When comparisons are made at the same taxonomic level with the previous analysis, there are significant increases and decreases in the NISP of multiple taxa ($\chi^2 = 451.8$, $p < .001$). Clear differences between the two analyses are seen in the accompanying adjusted residuals, which demonstrate that the level of identification changed disproportionately among taxa. In general, the current analysis increased counts for *Lepus*, *Canis*, *Erethizon*, and the three medium-bodied artiodactyl species, *Ovis*, *Odocoileus*, and *Antilocapra*. On the other hand, the significantly low adjusted residuals for *Sylvilagus* suggests that the previous research may have favored the analysis of this single taxon over most other species. Discrepancies between the two datasets may be due to differences in methods, level of identification, and misidentification.

The difference in the total number of specimens analyzed between the two datasets is likely due to different methods of recording remains fragmented during recovery. In the present analysis, fragments that conjoin and have clean fractures were counted as a single specimen. I suspect that the previous analyst did not follow the same protocol, thereby increasing the NISP for many taxa as well as the total number of specimens analyzed.

Apparent misidentification, while infrequent, probably explains some differences between the two analyses. For example, as I have discussed, some cranial specimens were previously identified as *Castor canadensis*, but were in fact *Erethizon dorsatum*. Previously reported *Castor* specimens in Pithouse 30, Pithouse 3, Secondary Pit Structure 32, Pithouse 36, Secondary Pit Structure 49, Pithouse 56, Pithouse 60, Activity Area 8, and Activity Area 28 were all identified in the present analysis as *Erethizon* (Talbot, et al. 2000: Appendix G). Likewise, specimens identified as *Antilocapra americana* in the present analysis may be have been previously identified as *Ovis* or *Odocoileus*, although the paucity of data from the original analysis prevents me from identifying why pronghorn specimens were not originally identified in the collection. Considering that the bulk of the *Antilocapra* specimens consist of distal tibiae, astragali, malleoli, and mandibles that have a large number of identifying landmarks used to distinguish medium-bodied artiodactyl species in the region (Lawrence 1951), it is unlikely that these were considered unidentifiable and may have been misidentified due to the previous analyst's limited experience and comparative collections (Talbot, et al. 2000: 459).

As previously noted, my analysis also differs in the level of identification, with a greater number of specimens identified to the species level. This has added substantial data on the presence of species that may be useful for paleoenvironmental research, and will be discussed further in Chapter 4.

2.3 Surface Modifications

In this section, I describe the cultural modification of bone specimens. The most direct evidence for cultural use of animal remains are surface modifications that result from culinary processing, such as cutmarks generated during the skinning, disarticulation, and filleting; impact marks resulting from mechanical fracturing of long bones to access marrow or the reduction of bone portions into pot-sized portions used for grease extraction; and burned surfaces caused by the exposure of bone to high temperatures. Bone may also be modified for non-culinary purposes, such as the production of bone tools and ornaments.

2.3.1.1 Cutmarks

Cutmarks are produced during the disarticulation and filleting of meat from bone, but must be distinguished from similar marks produced by trampling, carnivore gnawing, and other processes. Cutmarks were identified under magnification based on their "V" cross-section, relative linearity, location, and the degree that multiple markings were parallel. Striations that are randomly located, have "U" cross-sections, and non-linear were attributed to abrasion and other possible agents; those with thick cross-sections are more likely to be the result of carnivore ravaging, especially when corresponding with puncture marks, pits, edge crenulation and other marks produced by carnivore teeth (Blumenschine et al. 1996).

The presence of cutmarks representing specific activities relating to the skinning, disarticulation of body parts, and filleting of meat may be used qualitatively to evaluate what activities occurred at Five Finger Ridge. For large mammals, I used Binford's (1981) classification to categorize cutmarks and identify the likely function. Similar classifications are not available for smaller mammals, but function may be inferred using a combination of Binford (1981) and other research on the processing of small game for food and fur (e.g., Charles 1997).

2.3.1.2 Impact Marks

Skeletal parts may be fractured or reduced in size in an effort to access highly nutritious fat content locked inside the marrow cavity and spongy bone matrix. This will potentially result in two diagnostic signatures: fragmentation rates corresponding with marrow yield, which will be discussed in Chapter 3, and the presence of percussion marks created by the use of hammerstones. Such marks are typically characterized by conchoidal impact marks, similar to those represented in the production of flaked stone tools, accompanied by fissures and spalls originating from the point of impact (Fisher 1995). On long bones, these are commonly found nearly opposite one another, resulting from the bone being placed on an anvil and cracked open using a hammerstone to access the marrow. This will frequently result in the bone fracturing into multiple parts, not all of which will have percussion marks. These will have other indications of green bone fracturing, such as spiral breaks (Reitz and Wing 2008). However, such indications may occur regardless of the responsible actor as long as the bone is relatively fresh and are not considered here.

Because similar conchoidal fracture mechanics may occur when canids apply compressing forces with their carnassials, it can be difficult to distinguish the responsible actor. In general, specimens with additional signs of carnivore ravaging, with numerous impact marks and crushing at one location, or with relatively small impact marks were attributed to non-human agents.

2.3.1.3 Burning

The presence of burning on skeletal elements may be used to identify culinary processing, such as roasting, of faunal resources. By determining the degree and location of burning on elements, it can be determined whether the assemblage was burned randomly or occurred as the result of butchering and cooking processes (Grayson 1988). If faunal remains were burned in the process of preparing meat for consumption, it is expected that only those skeletal portions that were exposed to a significant degree of heat would exhibit any burning, such as portions that lack sufficient quantities of meat to shield the bone from heat (e.g., the distal lower limb). This non-random pattern of burning can be used to understand how prehistoric peoples prepared carcasses for consumption, especially for those species that are small enough that they lack butchering marks. On the other hand, if bones were being burned after consumption, such as by disposing bones into or adjacent to hearths, there should be indiscriminate burning of the entire skeleton.

Burning was recorded according to its degree (light charring, dark charring, or calcined) and location. Light charring represents incomplete carbonization that resulted in light brown surfaces; this is frequently isolated to specific portions of a skeletal part, in which case the surface alteration was described as “isolated charring”. Classification into this category was made conservatively, as bone may become discolored through diagenetic processes. Dark charring is less ambiguous, identified by complete or nearly complete carbonization of the bone that results in dark brown to black color change and accompanied by more significant surface texture changes. Calcined bone is easily identified by dark gray to white color change and heavy structural changes in the bone. Specimens that has been heated to such a degree likely represents bone that was exposed to high or prolonged temperatures that are unlikely to have occurred during culinary processing (Stiner et al. 1995).

Non-random distribution of burning among skeletal portions was evaluated using chi-square. Calcined specimens, worked bone and other artifacts found in the assemblage were removed from analysis since these are less likely to represent culinary processing activities.

2.3.2 Medium-bodied Artiodactyl Modifications

2.3.2.1 Cutmarks

The distribution of surface modifications among artiodactyl skeletal parts are presented in Table 2.7-10. The frequency of cutmarks does not differ significantly across the three medium-bodied artiodactyl species when evaluated using chi-square analysis ($\chi^2 = 2.16$, $p = .34$). Since the frequency of cutmarks is too low to conduct chi-square analysis for individual skeletal parts, composite anatomical parts (Stiner 2002) were used to form a smaller set of analytical units. These units include the head (skull and mandible), neck (cervical vertebrae), axial (thoracic and lumbar vertebrae, ribs, sternum, and pelvis), upper forelimb (scapula and humerus), lower forelimb (radius/ulna, carpals, and metacarpal), upper hindlimb (femur), lower hindlimb (tibia, tarsals, and metatarsal), and feet (phalanges).

Cutmarks are unevenly distributed within both *Odocoileus* ($\chi^2 = 64.28$, $p < .001$) and *Ovis* ($\chi^2 = 99.54$, $p < .001$) anatomical units (Table 2.11). Cutmarks are most frequent on the upper forelimb for both species. To determine whether the relative frequency of cutmarks are similar between the two species, I compared the adjusted residuals provided by these chi-square analyses using rank-order correlation; there is a significant correlation (Spearman's rho = .83, p = .01), indicating that the frequency of these butchering marks are similar across the two species.

I was able to classify most cutmarks on artiodactyl specimens using the codes provided by Binford (1981). Table 2.12 tabulates the NISP counts for each identified cutmark type, and Table 2.13 summarizes the frequency of cut marks by function among the three artiodactyl species. The cutmarks identified represent the full range of butchering activities, including skinning, dismemberment (including disarticulation of stiff-bodied carcasses), and filleting. For the two most common artiodactyl species, *Ovis* and *Odocoileus*, there are no significant differences in the frequency of cutmark function types ($\chi^2 = 7.07$, $p = .07$).

A number of cutmarks were identified that could not be classified under Binford's system (listed as "other"), most of which represent unknown activities. The majority of the unassigned cutmarks do not occur on multiple specimens, and are less likely to represent regular, systematic processing techniques that were recognized by Binford (1981). One exception are multiple, long cutmarks parallel to the shaft on the ventral midsection of the rib, occurring on twenty-seven of the sixty-two specimens with unclassified cutmarks. I suspect that these represent the removal of the periosteum from the rib. This may have been required to separate the ribs, possibly in preparation for creating smaller cooking portions. Three hyoid specimens also exhibited cutmarks that likely represent the removal of the tongue.

Dismemberment of stiff-bodied animals is indicated by the presence of S-6, M-2, CV-3, Hd-3, and RCp-5 cutmarks. This suggests that at least some of the butchering process did not occur immediately after the death of the animal, although it does not necessarily mean that disarticulation of the carcass into smaller anatomical units occurred at Five Finger Ridge itself. Instead, these cutmarks indicate that there was a delay between the death of the animal and the butchering process, allowing for rigor mortis to set in. As Lupo (1994) points out, relatively late butchering may occur if there was a substantial lapse of time between when an animal was hit by a projectile and when it was recovered by the hunter. Alternatively, butchering may be postponed if the size of the hunting party is limited and transportation of the carcass requires additional help of individuals from the residential base. The presence of cutmarks representing dismemberment of stiff-bodied carcasses on both *Odocoileus* and *Ovis* indicate that such delays were common for both species. The frequency of these cutmarks are also equally abundant across all temporal periods (Fisher's exact: Period 1-2A: p = .14; Period 1-2B: p = .08; Period 2A-2B: p = 1.0).

The presence of chop marks on a small number (NISP = 12) of artiodactyl specimens is also indicative of disarticulation that required considerable force. The chop marks are almost entirely located at the intersection of anatomical parts (Table 2.14). Four of the twelve marks are located on the distal humerus and likely represents the separation of the upper and lower forelimb. An additional four are located on or just below the neck, and may correspond to the removal of the neck and head from the postcranial body. Chop marks on the cranial portion of the sacrum and on the calcaneus may have occurred during the removal of the pelvis and lower hind limb, respectively.

Cutmarks on neonatal artiodactyl specimens are comparatively rare (Table 2.15). Five of the eleven specimens exhibiting cutmarks are from the skull, four of which are the result of skinning. This suggests that newborn artiodactyls may not have been targeted as a dietary resource alone.

The frequency of cutmarks among artiodactyl skeletal elements are much lower than those reported by Talbot et al. (2000: 485) despite the deeper level of analysis conducted for the present research. The previous analyst identified cutmarks on 14.8% of *Ovis* and 13.9%

of *Odocoileus* remains, compared to 11.8% and 9.7%, respectively, reported here. This may be the result of my more conservative approach to the ascription of marks as cutmarks, as described in Section 4.1.1.1. Specifically, modifications previously attributed as cutmarks may have been identified in the present analysis as other surface modifications, such as abrasion and carnivore gnawing.

For comparison, the frequency of carnivore marks was computed for the artiodactyls, excluding specimens that underwent digestive polishing since the original report does not describe this particular modification as being present in the Five Finger Ridge collection. Talbot et al. (2000: 486) report a frequency of 4.0% for large mammals; here, the frequency increased to 9.0% (NISP = 407), although this is restricted to medium-bodied artiodactyls. Although not conclusive, the shifting frequencies of cutmarks and carnivore gnaw marks suggests that the latter were potentially misidentified in the original analysis.

2.3.2.2 Impact Marks

Impact markers were common in the Five Finger Ridge assemblage (Tables 2.7-10). When all artiodactyl specimens are analyzed collectively, the distribution of impact markers on marrow-yielding bones (limbs, metapodials, phalanges, and mandible) is uneven (χ^2 = 372.2, $p < .001$), with the humerus and metacarpals having much higher frequency than expected. However, the adjusted residuals do not correlate with the quantity of marrow present (Spearman's rho = .267, $p = .488$), indicating the relative abundance of impact markers does not reflect intensity of marrow processing. Instead, the uneven distribution of impact marks may be the related to differences in cortical bone structure among marrow-yielding elements or the difficulty in identifying long bone shaft fragments to skeletal element. Nonetheless, the presence of hammer-and-anvil markers indicates that people were actively breaking open marrow-yielding bones.

2.3.2.3 Burning

Among the artiodactyls, burned specimens are relatively infrequent (Tables 7-10), and the frequency of burning among the three medium-bodied artiodactyls does not differ significantly ($\chi^2 = 1.75$, $p = .42$). As I did for the distribution of cutmarks, I used anatomical units to identify non-random patterns of burning using chi-square due to the small sample sizes for skeletal elements. The results show that burning is evenly distributed across anatomical parts for the combined artiodactyl assemblage ($\chi^2 = 7.30$, $p = .40$). The lack of patterned burning across the skeleton may be due to fortuitous burning and not roasting activities. No burning was evident on neonatal artiodactyl specimens.

2.3.2.4 Worked Bone

The bulk of the worked bone assemblage was removed from the collection prior to my analysis and described in the original report (Talbot et al., 2000: 402-412). However, not all worked bone was removed and such specimens, represented by various indicators of grinding, splitting, and polishing, are common in the materials I analyzed (NISP = 302).

The majority of the worked bone specimens identifiable to taxon are produced from artiodactyl bone (NISP = 109), while only three specimens were identified as *Lepus* and one as *Sylvilagus*. The majority of the artiodactyls specimens are metapodials (NISP = 92), the bulk of which were identified as deer (*Odocoileus* NISP = 45; *Ovis* NISP = 11; unassigned artiodactyl NISP = 36).

The most common modification represent a groove-and-snap technique (Dalley 1973) along the shaft of metapodials, identified by numerous, deep, parallel striations and polishing. The large frequency of worked *Odocoileus* metapodials may indicate that this was the preferred taxon for producing bone tools from metapodials due to the grooved morphology. *Antilocapra* metapodials have a similar morphology, and some of the unassigned artiodactyl work bone specimens may have been produced from this species as well.

A large portion of the worked bone specimens came from floor and subfloor contexts (worked bone floor NISP = 84). To determine whether worked bone came from specific contexts at a higher frequency than expected from sample size alone, I used regression analysis to compare worked bone NISP with total artiodactyl NISP. The values for worked bone are taken from Talbot et al. (2000: 402-412) since these include finished tools. Based on the standardized residuals, the Pithouse 20 fill, Pithouse 36 fill, Pithouse 56 fill, Pithouse 57 fill, Pithouse 61 fill, Pithouse 71 fill, and Pithouse 79 fill have significantly higher number of worked bone specimens than expected ($r^2 = .49$, $p < .001$; Figure 2, Table 2.16).

High frequencies of unworked metapodials in some contexts may represent debris from specialized bone tool production (see Appendix B for skeletal part counts per provenience). A regression between the unworked metapodial NISP and the total artiodactyl NISP (neonatal specimens excluded) demonstrates that the abundance of unworked metapodials in a particular provenience is a function of sample size ($r^2 = .47$, $p < .001$; Figure

3, Table 2.17). However, a subset of site contexts are significant outliers: Activity Area 9 fill, Pithouse 30 fill, Pithouse 45 fill, Pithouse 48 fill, Pithouse 60 fill, and Pithouse 60 floor all have larger numbers of unworked metapodials than expected from their respective sample sizes. As Table 2.17 and Figure 2.3 show, none of these contexts have a significantly larger number of worked bone specimens than expected.

It is likely that the abundance of unworked metapodials in these locations represent marrow processing activity. While only three worked bone specimens exhibited hammer impact notches, such markers are frequent among metapodials from the unmodified faunal assemblage (Table 2.7-10), including those contexts with higher than expected numbers of unworked metapodials. Although the process of producing worked bone could feasibly remove any impact markers present, it seems unlikely considering the percussion impacts result in unpredictable fragmentation with spiral fractures that would have prohibited production of regularly-shaped tools.

It is worth briefly mentioning that some other unusual uses of skeletal parts for tools and non-utilitarian functions were identified during the reanalysis of the Five Finger Ridge assemblage. Two *Ovis* upper molars exhibited significant amounts of battering on the occlusal surface that suggests they were used as a tool for an unknown function. I am not aware of evidence for teeth being used as tools elsewhere in the Fremont region. Thirteen specimens also had possible ocher staining, only two of which are worked bone specimens. One particularly interesting specimen is a long bone shaft fragment that has been incised with a spiral pattern with embedded ocher.

2.3.3 Leporid Modifications

2.3.3.1 Cutmarks

Cutmarks are rarely identified in rabbit remains in general, partly due to the difficulties in distinguishing such marks on small bone specimens, as well as the fact that leporids can be easily disarticulated without cutting tools. Only two *Sylvilagus* specimens exhibited cutmarks. One specimen, a third metatarsal, exhibited two parallel, deep grooves just distal to the proximal articular surface. These marks may represent an attempt to cut the proximal end for the manufacture of small bone tube beads. No such beads are described in the original report and may not have been recovered due to screen recovery biases. Cutmarks were also identified on the medial-ventral surface of the lateral process on a *Sylvilagus* lumbar vertebra, possibly resulting from the removal of the backstraps from a cottontail rabbit.

Three *Lepus* specimens exhibited possible cutmarks. The lateral process of a lumbar vertebra exhibited marks similar to that found in the *Sylvilagus* specimen above. Diagonal marks that may have been the caused by cutting actions were present on the center-distal shaft of a tibia. A distal femur had cutmarks consistent with Binford's (1981) Fd-1, which he attributes to dismemberment. An additional three *Lepus* specimens had been worked. One femur shaft has been cut completely through the proximal shaft, and may be the by-product of bone bead or tool manufacturing. A second proximal femur specimen exhibited a flattened and polished break at the proximal-center shaft. The third *Lepus* specimen is an ulna with a grounded and polished proximal end and striations along the shaft, indicating it may have been a finished tool.

2.3.3.2 Impact Marks and Fragmentation Rates

Only four *Lepus* specimens exhibited impact marks (three femora and one tibia), three of which are associated with Activity Area 9 (one in the fill, and two in the fill below AA9 and above AA8). The low incidence likely reflects the thin structure of leporid long bones combined with the small size of the individual animal. Hammerstone technology may not even be necessary, as marrow can be accessed from long bones through snapping or biting the articular ends off to expose the shaft marrow (Hockett and Haws 2002).

2.3.3.3 Burning

There are relatively low rates of burning (0.8%) among the *Sylvilagus* remains. Such burning is unevenly distributed among skeletal elements ($\chi^2 = 27.16$, $p = .007$). The tibia has a higher frequency of burning than expected, while lower rates of heat alteration than expected are found on the cranium. Figure 4 graphs the distribution of burning using the chi-square adjusted residuals, and further illustrates that burning is generally found on the appendicular skeleton.

For *Lepus*, burning is also relatively rare (1.6% of remains). Due to the small number of specimens with burning, chi-square analysis could not be conducted but the distribution of burning among skeletal elements is displayed in Figure 5. Three of the radius/ulna specimens were recovered from a hearth in Structure 22, resulting in the inflated values compared to the remaining skeletal elements.

Overall, it appears burning is most common on the appendicular skeletal of leporids, likely reflecting the roasting of the meatier portions of the animal, albeit at relatively low rates that imply that other culinary processing methods involving indirect heat (e.g., stewing) occurred more frequently at Five Finger Ridge.

2.3.4 Modifications among other taxa

The frequencies of cutmarks, burning, and impact markers among taxa not previously discussed are tabulated in Table 2.18. When applicable, Binford's (1981) classification of cutmarks was used, though with some reservation regarding function considering the differences in morphology between each of these species. Considering that a large number of the taxa listed in Table 2.14 are fur-bearing animals, it is likely that some cutmarks represent skinning of the animal and may not directly correspond with the culinary functions described by Binford (1978).

2.3.4.1 *Bison*

Two rib specimens of bison exhibited cutmarks consistent with Binford's (1981) RS-1, and likely represent filleting activities. A distal phalanx also exhibited dark charring indicating exposure to fire. Considering the lack of burning on other elements comprising the distal limbs, it is possible that the burning does not represent roasting activities but deposition proximate to fires.

2.3.4.2 *Castor canadensis*

One beaver metapodials exhibited shallow, angled cutmarks at the proximal end that may represent skinning. In addition, a scapula exhibited cutmarks on the medial face similar to Binford's (1981) Sc-4, attributed to filleting. Burning is present in only one specimen, a calcaneus with isolated charring on the midshaft.

2.3.4.3 *Marmota flaviventris*

A single mandible had transverse cutmarks on the ventral surface of the mandibular symphasis (M-1) that may represent the skinning of the head. A second specimen, a distal end and shaft of a tibia, had transverse cutmarks on the anterior mid-shaft.

2.3.4.4 *Thomomys* sp.

While rare, burning is present on five pocket gopher specimens. One specimen, a complete humerus, was recovered from a hearth feature from Pithouse 38, and was likely burned as a result of this context and not for culinary purposes. Light to dark charring is present on a proximal humerus, a proximal femur, a mandible, and a maxilla. As with the low levels of burning in *Sylvilagus*, it is difficult to interpret such infrequent levels of burning as the result of roasting.

2.3.4.5 *Lynx* spp.

Long, parallel striations were present along the entire shaft of two *L. rufus* ulnae. As discussed above in Section 2.2, these two specimens appear to belong to the same individual.

Charles (1997) notes similar cutmarks on a single lynx ulna specimen from Aveline's Hole, England, and attributes these to meat filleting. The single specimen attributed to *L. canadensis*, an innominate, had cutmarks adjacent to the acetabulum on the ischium (PS-8) that is consistent with dismemberment. This specimen also exhibited light charring on the cranial portion of the ilium. The combination of cutmarks and burning on *Lynx* spp. specimens suggests that these may have been prepared for consumption, although it is probable that these taxa were exploited for their furs as well.

2.3.4.6 *Ursus americana*

Two distal phalanges from a subfloor feature in Pithouse 56 have cutmarks on the proximal dorsal surface. No cutmarks were observed on a third phalanx specimen recovered from the floor of this pithouse. Charles (1997) reports cutmarks on Ursidae phalanges from Upper Paleolithic contexts that are attributed to skinning, and it is likely that the *Ursus* phalanges in Pithouse 56 represents the non-dietary use of bears for their fur or feet.

2.4 Taxonomic Diversity

2.4.1 Taxonomic Diversity between Temporal Periods

The distribution of taxa among dated contexts is presented in Table 2.19, alongside diversity values. Taxonomic richness and the reciprocal of the Simpson's Index of evenness (Magurran 1988) is computed for each assemblage using the number of exclusive categories based on taxonomic rank and the NISP derived from these categories. These exclusive categories are generally at the level of genus (combining multiple species in some cases, such as *Neotoma* spp. and *Sylvilagus* spp.) or family (when multiple genera were not present). For example, unassigned artiodactyl specimens are not considered in the taxonomic diversity measures if *Ovis* specimens are present. However, if no artiodactyls specimens were identified as *Ovis*, *Odocoileus*, *Antilocapra*, or *Bison*, taxonomic richness would include artiodactyls at the family level (see Grayson 1991 for the protocol used).

The number of taxa present in an assemblage (taxonomic richness) is frequently a function of sample size (Grayson 1984). As such, it is necessary to determine whether the number of taxa found across different assemblages at Five Finger Ridge is a reflection of assemblage size or meaningful in other ways. Regression analysis shows that there is highly significant relationship ($r^2 = .93$, $p = .03$) between sample size and the number of taxa, indicating that the inclusion of additional species into an assemblage is primarily a function of sample size, not behavioral differences such as diet breadth. What this relationship does not tell us, however, is what may be causing some assemblages to be larger, what the actual composition of the taxa are, nor how the specimens are distributed among the taxa.

Taxonomic evenness is used to address this last point by quantifying the degree that a single taxon is dominating an assemblage. The reciprocal of the Simpson's Index is used here since it is least prone to sample size effects compared to alternative evenness measures (Magurran 1988), and measures the degree to which an assemblage is dominated by a single taxon, with increasing values as specimens become more evenly distributed among taxa (Lyman 2008; Magurran 1988). As can be seen from the values in Table 2.19, taxonomic evenness is roughly comparable between the four temporal periods, and there does not appear to be a significant relationship with sample size ($r^2 = .66$, $p = .19$).

Such diversity measures do not, however, account for the taxonomic composition of each assemblage, changes in which might be reflective of local availability and use of various animal resources. There appear to be changes in the relative abundance of a number of taxa that may be reflective of climatic conditions, resource use, or a combination of the two factors. For example, the relative frequencies of the two *Sylvilagus* species appear to oppose each other through time, a shift that is unlikely to be related to human behavioral changes and instead are indicators of local climate change. In Chapter 4, I will identify and discuss such changes in the taxonomic composition in depth.

2.4.2 Taxonomic Diversity across Site Contexts

I have used the same taxonomic diversity measures to determine whether some contexts differed significantly in their abundance or dominance of taxa. The diversity measures were computed for individual floor and subfloor contexts using the same protocol discussed above. Values for each context are presented in Table 2.20-21. As with the analysis of taxonomic richness among temporal periods, there is a significant log-linear relationship between NISP and the number of taxa, indicating that taxonomic richness is being determined by sample size ($r^2 = .87$, $p < .001$; Figure 6). Only four contexts are significant outliers, all of which have total NISP values of five or less. Storage Structure 1 and Storage Structure 51 have higher number of taxa given their sample sizes, while Secondary Pit Structure 44 and Secondary Pit Structure 63 have fewer taxa compared to their sample sizes. There is no predictable relationship between sample size and the reciprocal of Simpson's Index ($r^2 = .01$, $p < .50$; Figure 7).

2.5 Conclusions

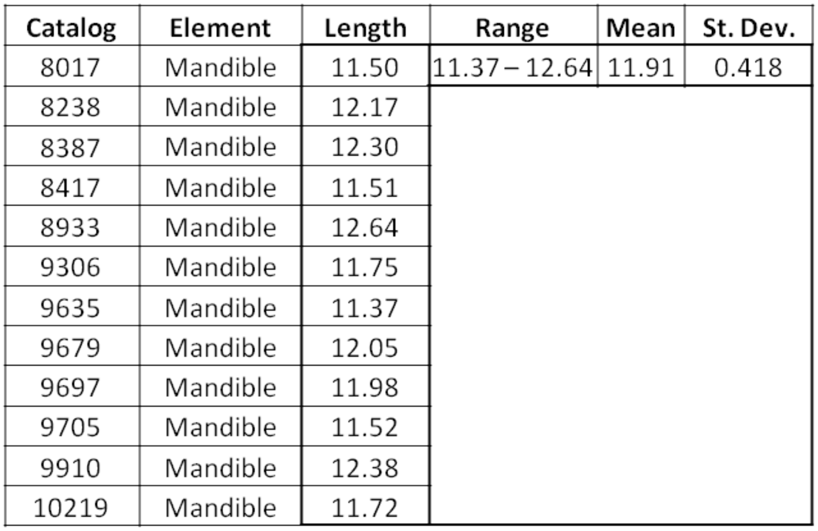
My reanalysis of the mammalian assemblage recovered from Five Finger Ridge resulted in significantly more precise level of identification with a larger number of specimens identified to taxon. The focus of this chapter has been on the descriptive summary of the faunal remains, with little emphasis on temporal or spatial patterning. In order to identify such patterns that may be meaningful for our understanding of human behavior, I must first assess the taphonomic history of the Five Finger Ridge assemblage to separate the patterns resulting from cultural activities from post-depositional processes that have altered the distribution and frequency of the remains. This task will be undertaken in the following chapter.

Tables

Table 2.1. Mammalian fauna identified at Five Finger Ridge by J. Fisher (JLF) and Michael Hall of Brigham Young University (BYU)

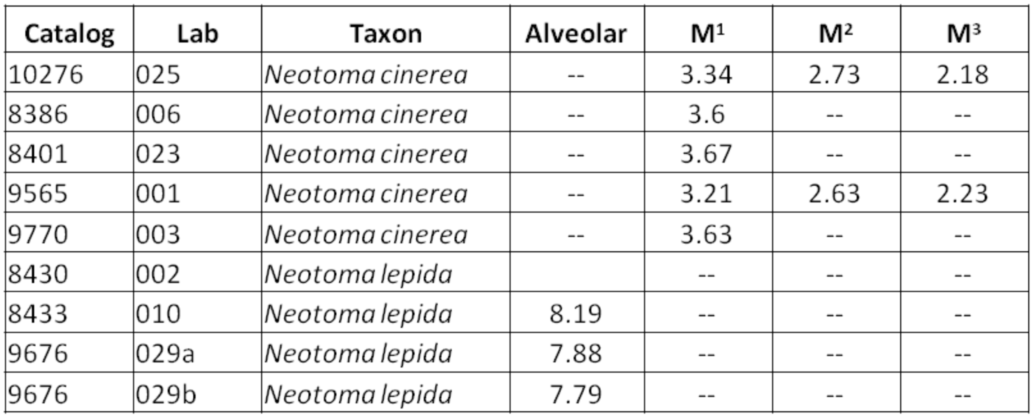
Order	Family	Taxon	NISP (JLF)	NISP (BYU)
Chiroptera/ Insectivora		Chiroptera /Insectivora	3	0
Lagomorpha		Leporidae, unassigned	238	619
		Lepus sp.	1729	563
		Sylvilagus spp.	8515	4973
		Sylvilagus audubonii	98	0
		Sylvilagus nuttallii	119	0
Rodentia		Rodentia, unassigned	248	--
	Sciuridae	Sciuridae, unassigned	79	74
		Ammospermophilus leucurus	3	0
		Cynomys sp.	2	2
		Marmota flaviventris	16	23
		Spermophilus sp.	12	130
		Spermophilus variegatus	210	0
		Tamias sp.	4	0
	Geomyidae	*Thomomys* sp.	440	777
		Thomomys bottae	394	0
	Heteromyidae	*Dipodomys* sp.	1	1
		Dipodomys microps	1	0
		Dipodomys ordii	2	0
		Perognathus sp.	3	0
	Castoridae	*Castor canadensis*	47	38
	Muridae, Sigmodontinae	*Peromyscus* sp.	19	41
		Crecetinae	1	0
		Neotoma spp.	8	88
		Neotoma cinerea	25	0
		Neotoma lepida	42	0
	Muridae, Arvicolinae	*Microtus* sp.	21	79
		Microtus longicaudus	6	0
		Ondatra zibethicus	50	31
	Erethizontidae	*Erethizon dorsatum*	34	5
Carnivora		Carnivora	14	--
	Canidae	*Canis* sp.	23	10
		Canis familiaris	1	--
		Canis latrans	4	--
	Ursidae	*Ursus americanus*	11	13
	Mustelidae	*Mustela frenata*	14	10
	Mephitidae	*Spilogale gracilis*	1	0
	Felidae	*Lynx canadensis*	1	0
		Lynx rufus	7	3
Artiodactyla		Artiodactyla	2520	--
	Cervidae	*Odocoileus hemionus*	838	311
	Antilocapridae	*Antilocapra americana*	40	0
	Bovidae	*Bison bison*	32	39
		Ovis canadensis	917	334
Total Identified			16,793	8,392
Total Unidentified			24,611	35,949
TOTAL			41,404	44,341

Table 2.2. Mandible alveolar lengths for Spermophilus variegatus. All measurement in millimeters.



Catalog	Element	Length	Range	Mean	St. Dev.
8017	Mandible	11.50	11.37 – 12.64	11.91	0.418
8238	Mandible	12.17			
8387	Mandible	12.30			
8417	Mandible	11.51			
8933	Mandible	12.64			
9306	Mandible	11.75			
9635	Mandible	11.37			
9679	Mandible	12.05			
9697	Mandible	11.98			
9705	Mandible	11.52			
9910	Mandible	12.38			
10219	Mandible	11.72			

Table 2.3. Maxillary alveolar and tooth lengths for Neotoma spp. All measurements in millimeters.



Catalog	Lab	Taxon	Alveolar	M^1	M^2	M^3
10276	025	*Neotoma cinerea*	--	3.34	2.73	2.18
8386	006	*Neotoma cinerea*	--	3.6	--	--
8401	023	*Neotoma cinerea*	--	3.67	--	--
9565	001	*Neotoma cinerea*	--	3.21	2.63	2.23
9770	003	*Neotoma cinerea*	--	3.63	--	--
8430	002	*Neotoma lepida*		--	--	--
8433	010	*Neotoma lepida*	8.19	--	--	--
9676	029a	*Neotoma lepida*	7.88	--	--	--
9676	029b	*Neotoma lepida*	7.79	--	--	--

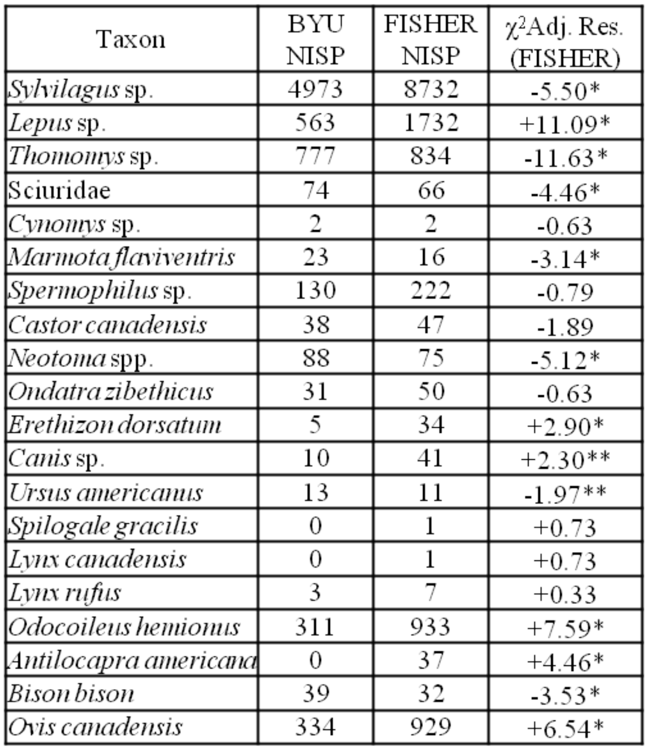
Table 2.4. Mandibular alveolar and tooth lengths for Neotoma spp. All measurements in millimeters.

Catalog	Lab	Taxon	Alveolar	M_1	M_2	M_3
8387	060	*Neotoma cinerea*	--	3.33	3.05	--
8395	002	*Neotoma cinerea*	--	3.51	3.18	2.34
8401	024	*Neotoma cinerea*	--	3.82	--	--
8415	028	*Neotoma cinerea*	--	3.4	--	--
8433	009	*Neotoma cinerea*	--	3.32	--	--
8401	026	*Neotoma lepida*	7.45	--	--	--
8428	007	*Neotoma lepida*	7.77	--	--	--
8433	007	*Neotoma lepida*	--	3.09	--	--
8433	008	*Neotoma lepida*	--	3.14	2.36	--
8488	004	*Neotoma lepida*	--	2.86	2.41	1.65
8640	002	*Neotoma lepida*	7.27	2.99	--	--
9565	002	*Neotoma lepida*	--	2.76	--	--
9787	050	*Neotoma lepida*	--	2.89	--	--
9962	009	*Neotoma lepida*	8.05	--	--	--
10218	012	*Neotoma lepida*	7.71	--	--	--
10218	013	*Neotoma lepida*	7.9	--	--	--
10218	014	*Neotoma lepida*	7.88	--	--	--
10276	024	*Neotoma lepida*	--	3.05	2.26	1.8
16926	122	*Neotoma lepida*	8.01	--	--	--
19006	002	*Neotoma lepida*	8.2	--	--	--

Table 2.5. Palatal measurements for Canis maxillary specimens. All measurements in millimeters.

Specimen	Length	Width	Ratio (l/2w)	Taxon
8261-033	67.48	9.26	3.64	*Canis latrans*
10236-022	58.75	11.05	2.66	*Canis familiaris*

Table 2.6. NISP per taxon for the original BYU and current Five Finger Ridge analyses, with adjusted residuals for the current analysis. *: $p < .001$; **: $p < .01$; ***: $p < .05$

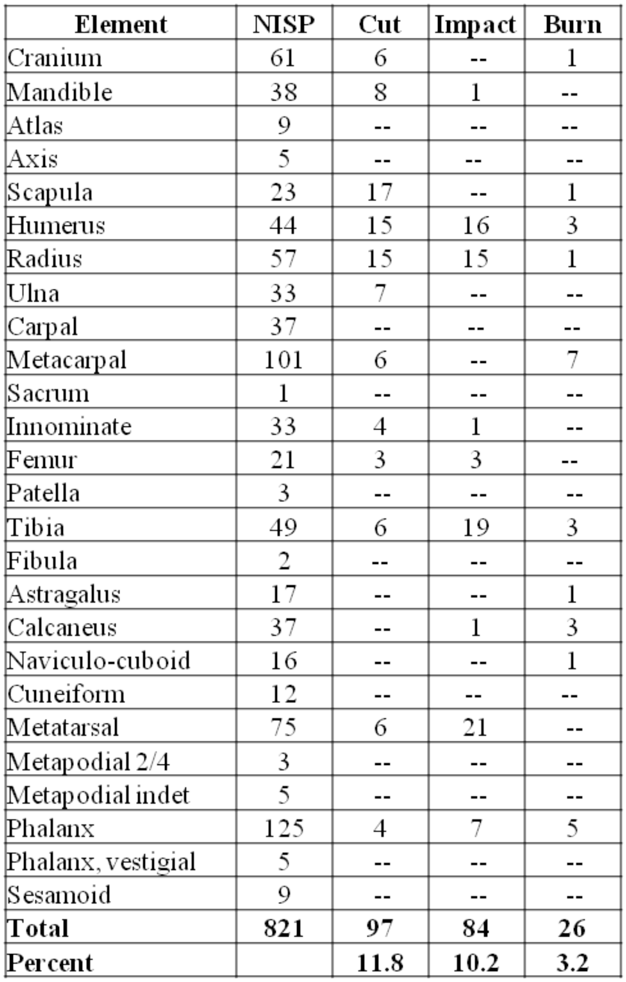


Taxon	BYU NISP	FISHER NISP	χ^2Adj. Res. (FISHER)
Sylvilagus sp.	4973	8732	-5.50*
Lepus sp.	563	1732	+11.09*
Thomomys sp.	777	834	-11.63*
Sciuridae	74	66	-4.46*
Cynomys sp.	2	2	-0.63
Marmota flaviventris	23	16	-3.14*
Spermophilus sp.	130	222	-0.79
Castor canadensis	38	47	-1.89
Neotoma spp.	88	75	-5.12*
Ondatra zibethicus	31	50	-0.63
Erethizon dorsatum	5	34	+2.90*
Canis sp.	10	41	+2.30**
Ursus americanus	13	11	-1.97**
Spilogale gracilis	0	1	+0.73
Lynx canadensis	0	1	+0.73
Lynx rufus	3	7	+0.33
Odocoileus hemionus	311	933	+7.59*
Antilocapra americana	0	37	+4.46*
Bison bison	39	32	-3.53*
Ovis canadensis	334	929	+6.54*

Table 2.7. Cultural markers on Odocoileus specimens. Worked bone and neonatal specimens removed.

Element	NISP	Cut	Impact	Burn
Cranium	82	3	--	3
Mandible	25	7	2	1
Atlas	4	--	--	--
Axis	3	--	--	--
Scapula	8	4	--	--
Humerus	45	17	22	--
Radius	24	2	4	--
Ulna	25	6	3	--
Carpal	23	1	--	1
Metacarpal	50	5	6	2
Sacrum	2	--	--	--
Innominate	30	3	2	2
Femur	18	2	5	3
Patella	2	--	--	--
Tibia	47	1	7	2
Fibula	7	--	--	1
Astragalus	29	1	--	3
Calcaneus	36	6	3	2
Naviculo-cuboid	16	1	--	3
Cuneiform	7	--	--	1
Metapodial 2/4	2	--	--	--
Metatarsal	128	8	21	4
Metapodial indet	5	--	--	1
Phalanx	82	2	9	1
Phalanx, vestigial	1	--	--	
Sesamoid	10	--	--	--
Total	**711**	**69**	**84**	**30**
Percent		**9.7**	**11.8**	**4.2**

Table 2.8. Cultural markers on Ovis specimens. Worked bone and neonatal specimens removed.



Element	NISP	Cut	Impact	Burn
Cranium	61	6	--	1
Mandible	38	8	1	--
Atlas	9	--	--	--
Axis	5	--	--	--
Scapula	23	17	--	1
Humerus	44	15	16	3
Radius	57	15	15	1
Ulna	33	7	--	--
Carpal	37	--	--	--
Metacarpal	101	6	--	7
Sacrum	1	--	--	--
Innominate	33	4	1	--
Femur	21	3	3	--
Patella	3	--	--	--
Tibia	49	6	19	3
Fibula	2	--	--	--
Astragalus	17	--	--	1
Calcaneus	37	--	1	3
Naviculo-cuboid	16	--	--	1
Cuneiform	12	--	--	--
Metatarsal	75	6	21	--
Metapodial 2/4	3	--	--	--
Metapodial indet	5	--	--	--
Phalanx	125	4	7	5
Phalanx, vestigial	5	--	--	--
Sesamoid	9	--	--	--
Total	**821**	**97**	**84**	**26**
Percent		**11.8**	**10.2**	**3.2**

Table 2.9. Cultural markers on Antilocapra specimens. Worked bone and neonatal specimens removed.

Element	NISP	Cut	Impact	Burn
Mandible	3	1	--	--
Scapula	1	--	--	--
Radius	4	1	--	--
Metacarpal	1	--	--	--
Tibia	8	--	2	--
Fibula	5	1	--	--
Astragalus	3	--	--	--
Naviculo-cuboid	1	--	--	--
Metatarsal	5	--	2	--
Phalanx	8	--	--	--
Total	**39**	**3**	**4**	**0**
Percent		7.7	**10.3**	**0.0**

Table 2.10. Cultural markers on combined medium-bodied artiodactyl specimens. Worked bone and neonatal specimens removed.

Element 2	NISP	Cut	Impact	Burn
Cranium	216	11	--	4
Mandible	80	22	3	2
Hyoid	14	5	--	1
Atlas	33	--	--	--
Axis	21	1	--	--
Cervical	107	1	--	1
Thoracic	139	4	--	2
Lumbar	141	5	--	1
Sacrum	23	--	--	1
Caudal	7	--	--	--
Rib	396	60	2	18
Costal Cartilage	11	--	--	--
Sternum	5	--	--	--
Scapula	69	38	--	1
Humerus	244	56	99	7
Radius	148	23	26	4
Ulna	96	21	5	1
Metacarpal	185	11	30	9
Carpal	64	1	--	1
Innominate	156	15	5	6
Femur	180	25	39	6
Patella	10	--	--	--
Tibia	303	18	68	11
Astragalus	56	1	--	5
Calcaneus	94	6	4	6
Fibula	14	1	--	1
Navicular-cuboid	36	1	--	4
Tarsal	73	2	--	1
Metatarsal	236	14	44	4
Metapodial 2/4	8	--	--	1
Metapodial indet	117	1	25	3
Sesamoid	24	--	--	--
Phalanx	325	7	34	8
Phalanx, vestigial	19	--	--	--
Total	**3650**	**350**	**384**	**109**
Percent		**9.6**	**10.5**	**3.0**

Table 2.11. Distribution of cutmarks across anatomical units for *Odocoileus* and *Ovis* with chi-square adjusted residuals. *: p < .001; **: p < .01; ***: p < .05.

Anatomical Unit	*Odocoileus*			*Ovis*		
	Cut	Uncut	Adj. Res. (Cut)	Cut	Uncut	Adj. Res. (Cut)
Head	10	97	-0.18	14	85	+0.59
Neck	0	7	-0.88	0	14	-1.42
Axial	3	29	-0.09	4	30	-0.10
Upper Forelimb	21	32	+7.58*	32	35	+9.25*
Lower Forelimb	14	108	+0.67	28	200	-0.03
Upper Hindlimb	2	16	+0.19	3	18	+0.28
Lower Hindlimb	17	253	-2.49***	6	130	-3.11**
Feet	2	91	-2.67**	4	135	-3.76*

Table 2.12. Butchering cuts for medium-bodied artiodactyls. Worked bone and neonatal specimens removed. Coding and function of cuts from Binford (1981).

Element	**Cut**	**Function**	***Odocoileus***	***Ovis***	***Antilocapra***	**Artio, unassigned**	**Total**
Skull	S-4	Skinning	1	4		1	6
	S-6	Dismembering (stiff/frozen)		1			1
Mandible	M-1	Skinning		2	1		3
	M-2	Dismembering (stiff/frozen)	2			2	4
	M-3	Dismembering	1	1			2
	M-4	Dismembering	1	2		1	4
	M-5	Dismembering	1	2		2	5
Cervical	CV-3	Dismembering (stiff/frozen)				1	1
Thoracic	TV-2	Filleting				5	5
Rib	RS-1	Filleting				20	20
	RS-2	Dismembering				4	4
	RS-3	Dismembering				8	8
Scapula	Sc-2	Dismembering	3	4			7
	Sc-3	Filleting	2	7		10	19
	Sc-4	Filleting	1	13		2	16
Humerus	Hp-3	Dismembering	1	1		1	3
	Hp-4	Filleting		2		1	3
	Hp-5	Filleting		7		4	11
	Hd-2	Dismembering (stiff/frozen)	7	3		3	13
	Hd-3	Dismembering (stiff/frozen)	2			2	4
	Hd-4	Dismembering		1			1
	Hd-5	Dismembering	2	1		2	5
	Hd-6	Filleting	5			5	10
	Hd-7	Filleting	4			3	7
Radius/Ulna	RCp-1	Dismembering	1			1	2
	RCp-2	Dismembering	2	3			5
	RCp-3	Dismembering	2			2	4
	RCp-5	Dismembering (stiff/frozen)		5		1	6
	RCp-6	Filleting		7		2	9
	RCp-7	Filleting	3	4		4	11
	RCd-2	Dismembering		1		1	2
	RCd-3	Dismembering				1	1
	RCd-4	Filleting		1	1	1	3
Metacarpal	MCp-1	Dismembering		1			1
	MCp-2	Dismembering	1				1
	MCd-1	Dismembering		2			2
	MCd-4	Filleting		2			2
Innominate	PS-1	Secondary butchering		1			1
	PS-7	Dismembering	2	2		1	5
	PS-8	Dismembering		2		3	5
	PS-10	Dismembering				3	3
Femur	Fp-1	Dismembering		2			2
	Fp-4	Filleting				3	3
	Fp-7	Filleting		1		1	2
	Fp-9	Filleting				8	8
	Fd-1	Dismembering				1	1
	Fd-4	Filleting	1			2	3
	Fd-5	Filleting				3	3
Tibia	Tp-3	Filleting		1		3	4
	Tp-5	Filleting		2			2
	Td-4	Filleting		2		4	6
Astragalus	TA-1	Dismembering	1				1
Calcaneus	TC-3	Filleting	6				6
Naviculo-cuboid	TNC-1	Dismembering	1				1
Metatarsal	MTp-3	Dismembering	1				1
	MTd-1	Dismembering		1			1
	MTd-2	Skinning	3	2			5
	MTd-4	Dismembering		1			1
Other	Other	Unknown	18	14	1	62	95
TOTAL			**75**	**108**	**3**	**184**	**370**

Table 2.13. Number of specimens with cutmark function types among artiodactyl taxa. Percent values based on total NISP for each taxon.

	Odocoileus	***Ovis***	***Antilocapra***
Skinning	4 (.4%)	8 (.9%)	1 (2.7%)
Dismembering	31 (3.3%)	36 (3.9%)	0 (0%)
Filleting	22 (2.4%)	49 (5.3%)	1 (2.7%)
Unknown	18 (1.9%)	14 (1.5%)	1 (2.7%)
Total	75 (8.0%)	107 (11.5%)	3 (8.1%)

Table 2.14. Frequency (NISP) of chop marks among artiodactyl elements.

Element	**Chop NISP**
Atlas	1
Axis	2
Cervical	1
Thoracic 1	1
Lumbar	1
Sacrum, cranial	1
Humerus, distal	4
Calcaneus	1

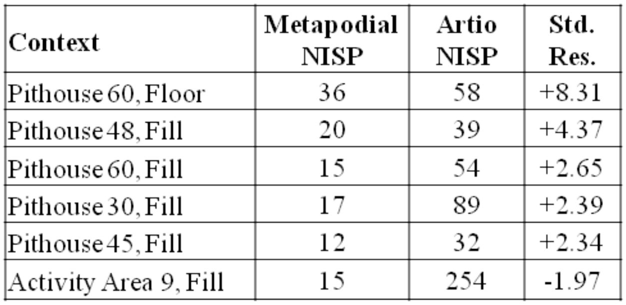
Table 2.15. Butchering marks for neonatal artiodactyls. Coding and function of cuts from Binford (1981).

Element	Cutmarks	Function	Neonatal Artiodactyl
Skull	S-4	Skinning	3
Mandible	M-1	Skinning	1
	M-5	Dismembering	1
Thoracic	TV-2	Filleting	1
Humerus	Hd-?	?	1
	Hd-7	Filleting	1
Radius/Ulna	RCp-5	Dismembering	1
Innominate	PS-10	Dismembering	1
Femur	Fd-1	Dismembering	1
TOTAL			**11**

Table 2.16. Standardized residuals for Five Finger Ridge contexts that fall significantly from the worked and total artiodactyl NISP relationship.

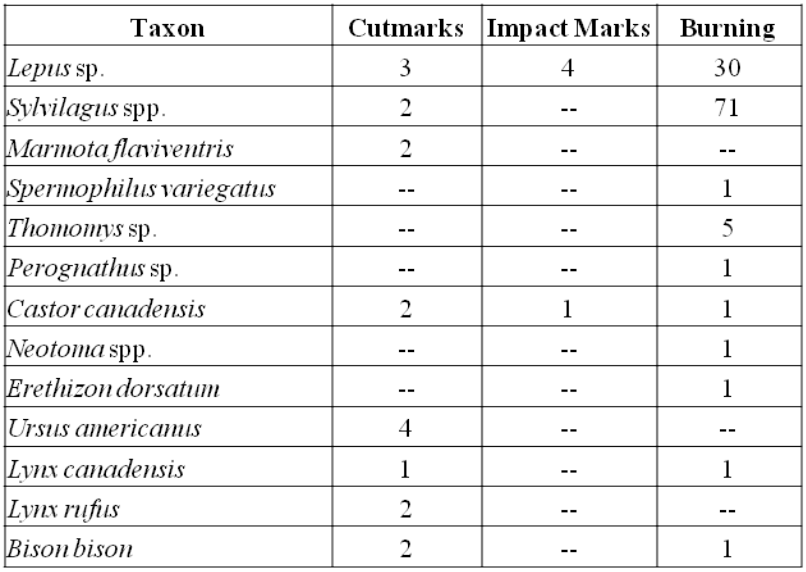
Context	Worked NISP	Artio NISP	Std. Res.
Pithouse 57 Fill	25	81	+4.12
Pithouse 20 Fill	20	31	+3.95
Pithouse 56 Fill	21	94	+2.77
Pithouse 36 Floor	13	6	+2.68
Pithouse 79 Fill	16	63	+2.17
Pithouse 61 Fill	31	236	+2.15
Pithouse 79 Subfloor	11	9	+2.09
Pithouse 75 Floor	12	26	+1.96
Pithouse 28 Floor	10	175	-1.98
Activity Area 25 Subfloor	0	64	-2.07
Activity Area 28 Fill	6	154	-2.55

Table 2.17. Standardized residuals for Five Finger Ridge contexts that fall significantly from the unworked metapodial and total artiodactyl NISP relationship.



Context	Metapodial NISP	Artio NISP	Std. Res.
Pithouse 60, Floor	36	58	+8.31
Pithouse 48, Fill	20	39	+4.37
Pithouse 60, Fill	15	54	+2.65
Pithouse 30, Fill	17	89	+2.39
Pithouse 45, Fill	12	32	+2.34
Activity Area 9, Fill	15	254	-1.97

Table 2.18. Cultural markers among additional taxa.



Taxon	Cutmarks	Impact Marks	Burning
Lepus sp.	3	4	30
Sylvilagus spp.	2	--	71
Marmota flaviventris	2	--	--
Spermophilus variegatus	--	--	1
Thomomys sp.	--	--	5
Perognathus sp.	--	--	1
Castor canadensis	2	1	1
Neotoma spp.	--	--	1
Erethizon dorsatum	--	--	1
Ursus americanus	4	--	--
Lynx canadensis	1	--	1
Lynx rufus	2	--	--
Bison bison	2	--	1

Table 2.19. Taxonomic counts and diversity measures for each temporal period.

Taxon	Period 1	Period 2A	Period 2B	Period 3
Chiroptera/Insectivora	1	--	1	--
Leporidae, unassigned	20	8	21	4
Lepus sp.	181	94	106	10
Sylvilagus spp.	748	412	677	56
Sylvilagus audubonii	12	6	7	1
Sylvilagus nuttallii	7	9	15	--
Rodentia, unassigned	29	9	16	6
Sciuridae, unassigned	6	3	3	--
Cynomys sp.	1	--	--	--
Marmota flaviventris	1	--	--	--
Spermophilus sp.	--	1	1	--
Spermophilus variegatus	36	6	10	16
Thomomys sp.	31	47	25	6
Thomomys bottae	50	26	19	5
Perognathus sp.	1	--	--	--
Castor canadensis	--	2	5	--
Peromyscus sp.	1	3	--	--
Neotoma spp.	1	--	1	--
Neotoma cinerea	--	--	3	--
Neotoma lepida	2	1	1	--
Microtus sp.	--	1	--	--
Ondatra zibethicus	4	4	1	--
Erethizon dorsatum	1	1	5	--
Carnivora	8	--	1	--
Canis sp.	1	3	2	--
Canis latrans	1	--	--	--
Ursus americanus	--	--	5	--
Mustela frenata	2	2	2	--
Lynx canadensis	--	1	--	--
Lynx rufus	--	--	1	--
Artiodactyla	188	145	175	11
Odocoileus hemionus	63	59	76	5
Antilocapra americana	3	1	11	--
Bison bison	1	2	2	--
Ovis canadensis	86	26	79	--
Unidentified	2,146	1,662	2226	268
TOTAL NISP	**1,486**	**872**	**1,271**	**120**
TOTAL SPECIMENS	**3,632**	**2,534**	**3,497**	**388**
Taxonomic Richness	**18**	**17**	**18**	**5**
Taxonomic Evenness (1/D)	**2.38**	**2.49**	**2.16**	**2.66**

Table 2.20. Diversity measures for individual floor and subfloor contexts of structures. Contexts with significantly high taxonomic richness marked with asterisks (*: p < .05)**

Provenience	NISP	Richness	Evenness
Storage Structure 1***	3	3	--
Pithouse 2	32	3	1.39
Pithouse 3	195	9	1.84
Storage Structure 4	7	3	3.50
Pithouse 5	7	3	3.00
Pithouse 7	6	2	1.50
Pithouse 9	27	5	2.62
Pithouse 11	12	3	1.47
Pithouse 13	21	5	3.13
Pithouse 14	40	6	4.02
Secondary Pit Structure 16	2	2	--
Pithouse 17	35	7	4.08
Pithouse 20	51	5	1.85
Secondary Pit Structure 21	36	7	4.77
Pithouse 22	146	7	1.83
Storage Structure 23	1	1	--
Central Structure 24	41	6	2.76
Surface Structure 25	21	3	1.23
Pithouse 26	32	7	4.13
Pithouse 28	178	10	1.60
Pithouse 29	152	8	2.66
Pithouse 30	125	7	2.47
Pithouse 33	69	5	3.72
Pithouse 36	96	5	1.48
Storage Structure 37	1	1	--
Pithouse 38	102	5	1.52
Secondary Pit Structure 39	11	2	1.22
Pithouse 43	112	8	1.64
Secondary Pit Structure 44***	3	1	1.00
Pithouse 45	21	5	3.82
Pithouse 47	62	5	1.51
Pithouse 48	37	5	2.24
Secondary Pit Structure 49	5	3	5.00
Secondary Pit Structure 50	3	2	3.00
Storage Structure 51***	3	3	--
Pithouse 56	81	8	1.46
Pithouse 57	98	6	1.29
Secondary Pit Structure 59	1	1	--
Pithouse 60	69	7	3.71
Pithouse 61	30	5	1.24
Secondary Pit Structure 62	198	11	2.70
Secondary Pit Structure 63***	5	1	1.00
Pithouse 67	22	3	2.31
Pithouse 68	6	3	5.00
Pithouse 69	4	2	2.00
Pithouse 70	17	3	1.68
Pithouse 71	17	4	2.00
Storage Structure 72	1	1	--
Pithouse 74	9	2	1.29
Pithouse 75	27	5	3.62
Secondary Pit Structure 76	2	2	--
Pithouse 79	85	6	1.95
Storage Structure 80	3	2	3.00
Pithouse 81	8	3	2.55

Table 2.21. Diversity measures for individual floor and subfloor contexts of activity areas.

Provenience	NISP	Richness	Evenness
Activity Area 4	2	1	1.00
Activity Area 8	1	5	1.34
Activity Area 9	11	3	2.29
Activity Area 10	2	1	1.00
Activity Area 11	28	4	2.72
Activity Area 12	3	2	3.00
Activity Area 13	61	5	2.03
Activity Area 16	7	2	1.91
Activity Area 18	1	1	--
Activity Area 19	1	1	--
Activity Area 20	1	1	--
Activity Area 24	36	7	3.26
Activity Area 25	200	12	3.14
Activity Area 27	25	7	5.36
Activity Area 28	1	1	--
Activity Area 29	61	7	3.85

Figures

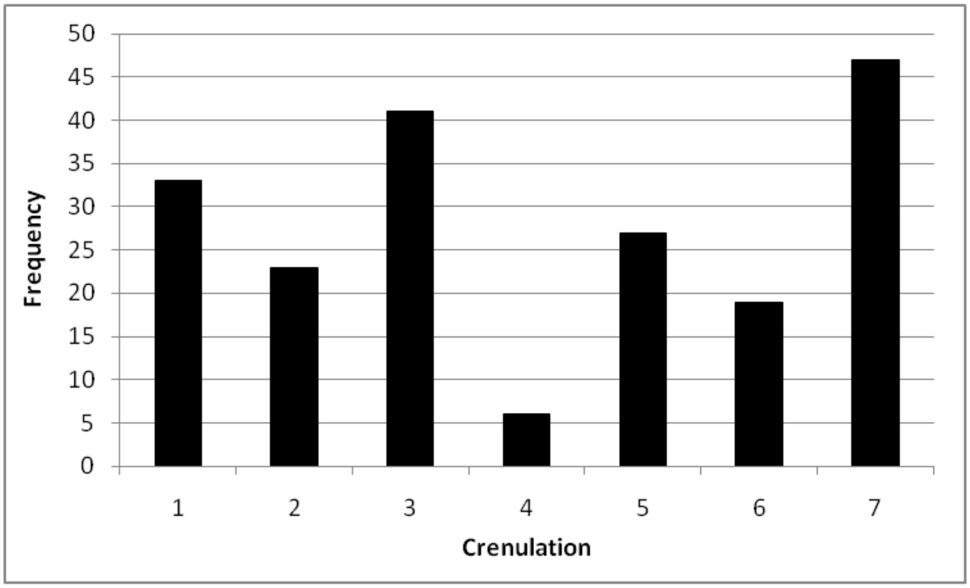


Figure 2.1. Frequency of Sylvilagus specimens among crenulation categories for the lower third premolar. (1) No Crenulation; (2) Simple to No Crenulation; (3) Simple Crenulation; (4) Simple to Moderate Crenulation; (5) Moderate Crenulation; (6) Moderate to Strong Crenulation; (7) Strong Crenulation. Specimens in categories 1-3 are S. nutallii, and those of categories 5-7 are S. audubonii.

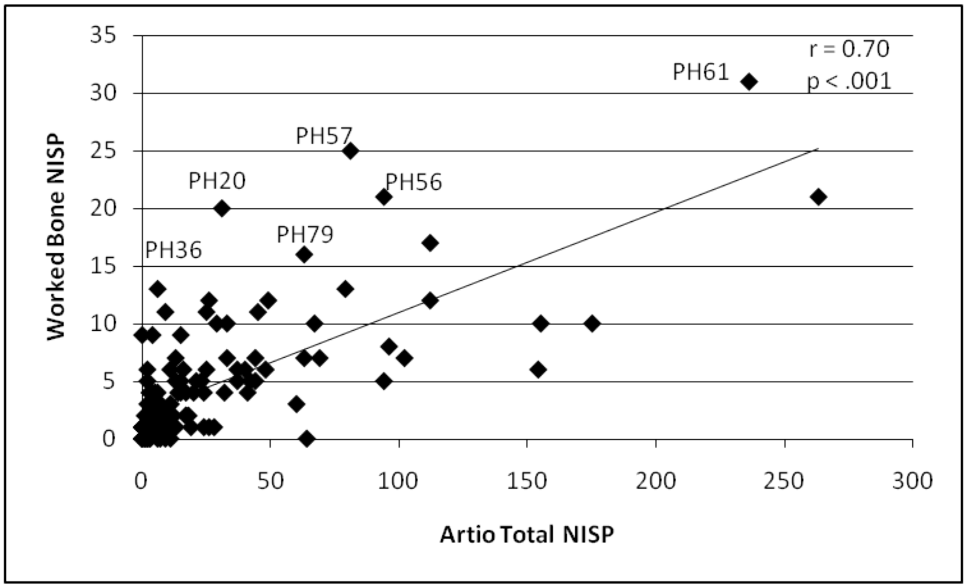


Figure 2.2. Relationship between artiodactyl total NISP and worked bone NISP among site contexts. Labeled proveniences fall significant distances from the regression line.

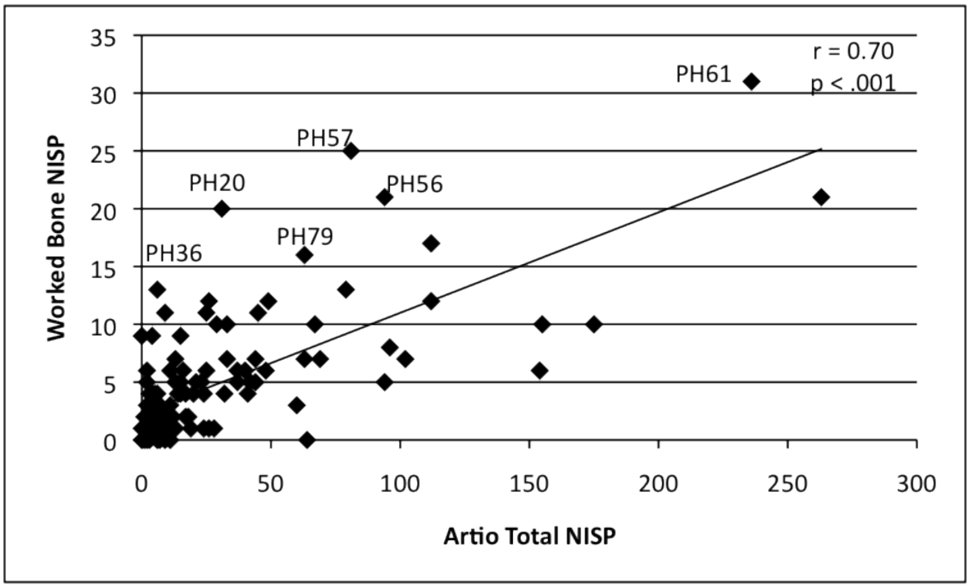


Figure 2.3. Relationship between artiodactyl total NISP and metapodial NISP among site contexts. Labeled proveniences fall significant distances from the regression line.

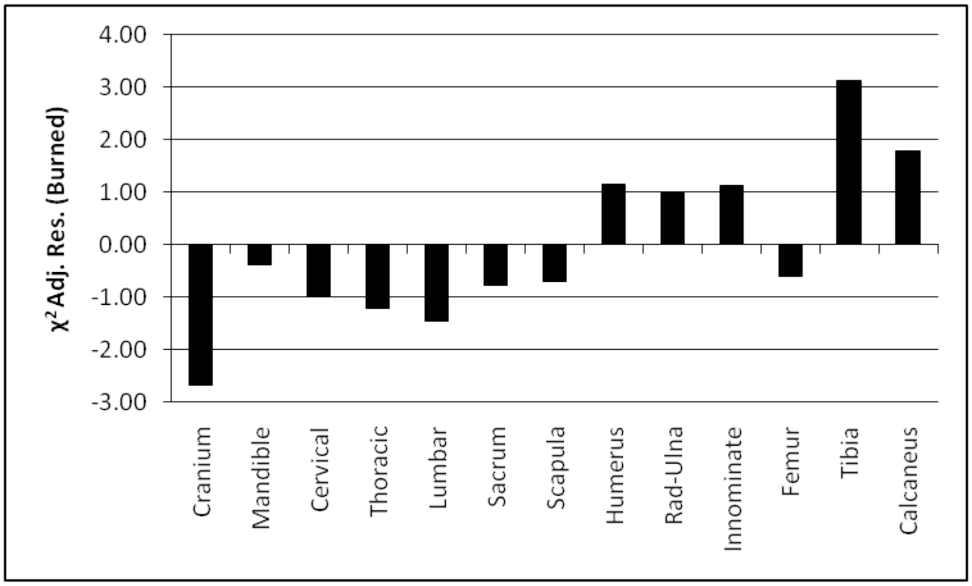


Figure 2.4. Chi-square adjusted residuals for the presence of burning among Sylvilagus skeletal elements. Elements not captured by ¼" screen removed (Shaffer 1996).

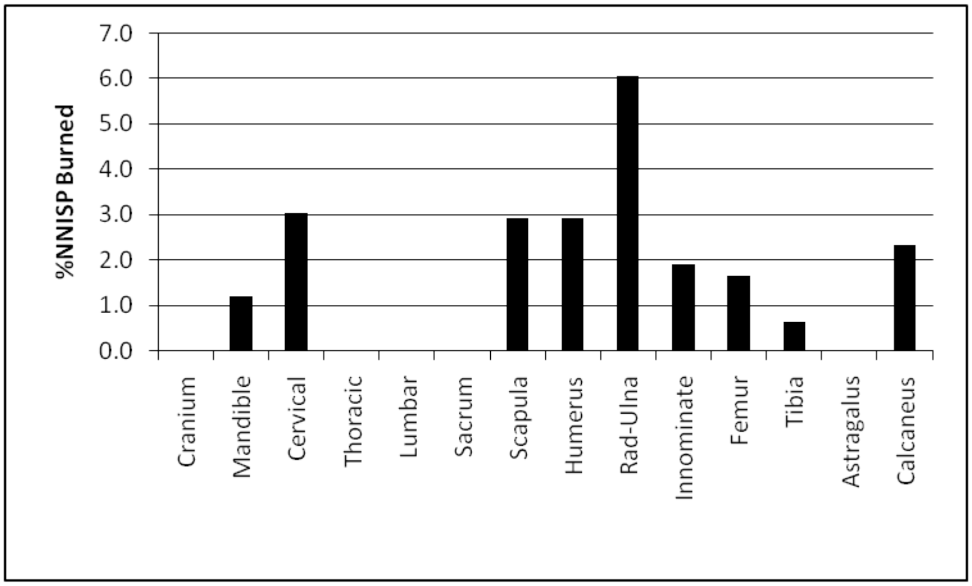


Figure 2.5. Distribution of burning among Lepus skeletal elements. Elements not captured by ¼" screen removed (Shaffer 1996).

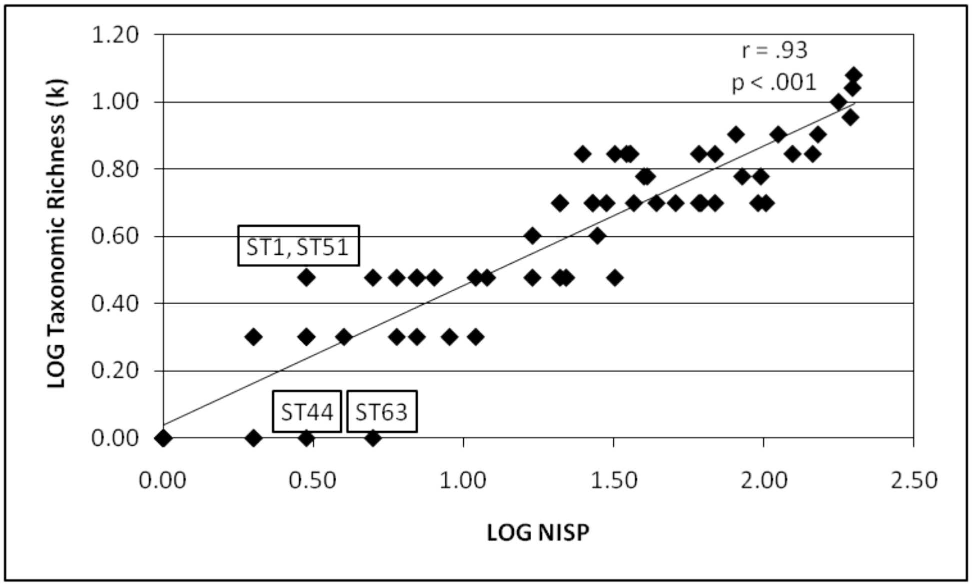


Figure 2.6. Regression of taxonomic richness against sample size for individual floor/subfloor contexts.

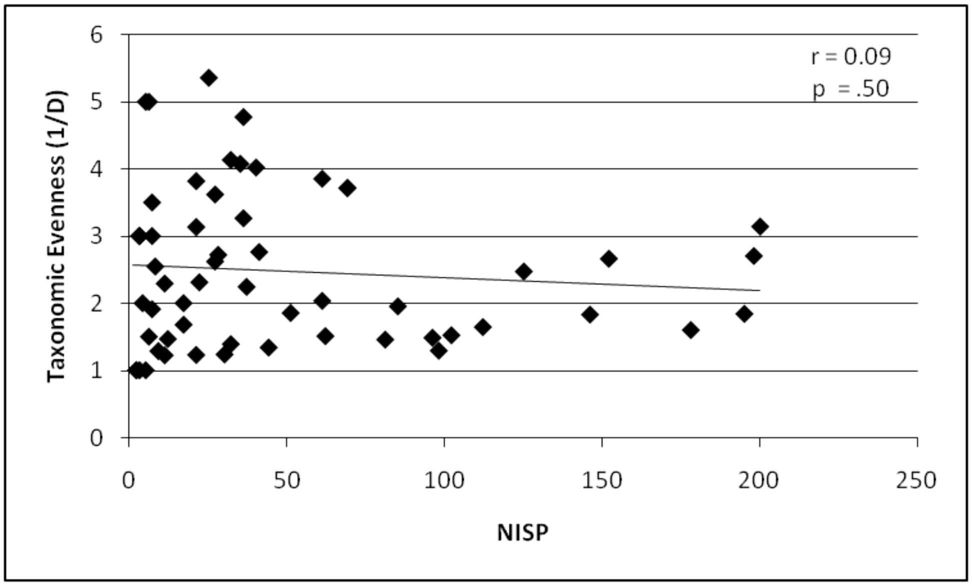


Figure 2.7. Regression of taxonomic evenness against sample size for individual floor/subfloor contexts.

Chapter 3

INTRASITE VARIABILITY IN TAPHONOMY

3.0 Introduction

The meaning of the relative abundances of mammalian taxa exploited by prehistoric peoples are obfuscated by various taphonomic processes that determine the likelihood of skeletal part survivorship at an archaeological site. Relative taxonomic abundances between sites and site contexts may not be a reflection of foraging decisions, but instead may be a product of differential survivorship that inflates or deflates the overall representation of taxa and their skeletal parts (e.g., Lam and Pearson 2005; Lam et al. 2003; Lyman 1984, 1985; Lyman 1994).

The goal of this chapter is two-fold. My first objective is to identify potential spatial differences in bone attrition to determine whether the distribution of skeletal parts among households is a reflection of sharing behaviors or simply an expression of the taphonomic history of the Five Finger Ridge assemblage. The second goal is to determine whether there are significant differences in density-mediated destruction between animals to determine whether relative taxonomic abundances between households and across time are a reflection of hunting behaviors and local resource availability and not the result of differing taphonomic trajectories. This analysis serves as a critical step before identifying real differences in the spatial distribution of skeletal parts and taxonomic frequencies between households and activity areas at the site.

3.1 Density-mediated Destruction

It is well recognized that the skeletal population recovered from an assemblage has undergone a large number of taphonomic processes that have altered the original population (see Lam, et al. 2003; Lyman 1994 for review). Density-mediated destruction analysis has proved to be an essential first step towards identifying cultural and behavioral patterns of animal resource use by identifying relationships between the density of skeletal parts and their relative frequency in an archaeological assemblage. Bone density values are computed for specific parts of the skeleton as defined by the sites scanned using photon densitometry, computed tomography, and a variety of other techniques (Lam, et al. 2003). Density-mediated destruction is evaluated by comparing the volume density values for these "scan sites" with the frequency that these parts were recovered from an archaeological site.

Research has generally focused on disentangling the equifinality between bone survivorship and cultural practices, especially in the process of developing inferences regarding transportation and access to animal resources (Grayson 1989; Lam and Pearson 2005; Lyman 1985; Lyman 1994; Marean et al. 1992). As such, analysis has tended towards using site-wide assemblages with a focus on large game. This is reflected by the large number of studies on bone density of large bodied mammals, such as sheep (Lam et al. 1998; Lyman 1984, 1985; Symmons 2005), goat (Brain 1981), deer (Lyman 1984), pronghorn (Lyman 1984), bison (Kreutzer 1992), camelids (Elkin 1995; Stahl 1999), equids (Lam et al. 1999), and seals (Chambers 1992). In comparison, leporids (Pavao and Stahl 1999) and marmots (Lyman et al. 1992) are the only small mammals with published bone density data to date.

3.1.1 Depositional Differences

Equifinality resulting from density-mediated destruction is not limited to inferences about transportation and access to animal resources. Faunal resources, especially those that come in large packages, are frequently distributed among households in an uneven manner depending on the underlying motivation for sharing (Chapter 1). But these patterns may be confused with spatial differences in bone survivorship that result in some skeletal portions surviving at a higher rate within specific site contexts due to different taphonomic trajectories. For example, two households with significantly high and low skeletal part richness may represent reciprocity (high richness) and tolerated scrounging or signaling (low richness) behaviors, respectively. Alternatively, it may be that the high richness value of one household is a reflection of lower levels of density-mediated destruction compared to the second household.

Intrasite variation in attrition may occur as a result of differing exposure to destructive elements. Bone waste that is left on the surface is more likely to suffer from weathering (Behrensmeyer 1978; Phoca-Cosmetatou 2005), trampling (Behrensmeyer et al. 1986; Olsen and Shipman 1988), and scavenging (e.g., Marean and Spencer 1991; Marean, et al. 1992; Munson and Garniewicz 2003) processes that systematically damage bone. In addition, carnivores may also serve as a transport agent by redepositing bone waste left behind by people (e.g., Kent 1981; Marean, et al. 1992). These destructive forces may result in certain proveniences having strongly positive relationship between volume density and element representation, such as abandoned use surfaces that are left exposed. In contrast, the process of disposing trash in designated areas may result in rapid accumulation of bone waste that is protected from these various processes.

Clearly, the variable impacts of density-mediated destruction must be analyzed between site contexts before attempting to identify significant patterns of skeletal part distributions among households. Indeed, even site-wide analyses of human behavior that require investigation of bone survivorship may need to look at the variability in attrition across site contexts before concluding whether an assemblage has been compromised by the taphonomic filter.

3.1.2 Culinary Processing and Carnivore Ravaging

Density-mediated destruction may also impact the relative abundances of taxa if animals had different taphonomic histories. As discussed in the first chapter, I predict that household taxonomic diversity should depend on whether individuals were focusing on signaling hunting or provisioning the household. However, higher rates of skeletal attrition for some taxa may result in lower taxonomic evenness (and possibly richness) for an archaeological assemblage than what was originally deposited.

Previous research on the impact of culinary processing on skeletal survivorship (e.g., Lupo 1995; Speth 2000; Ugan 2010) provides reason to believe that survivorship may vary among different kinds of animals. Culinary practices, such as roasting, stewing, marrow extraction, and grease processing, is dependent on a number of factors, such as the type of animal (Wandsnider 1997), the degree of resource stress (Church and Lyman 2003; Fisher and Johnson submitted; Outram 2004; Ugan 2005), technology, and cultural preferences. It is well recognized that humans and other animals frequently take advantage of fats that are locked inside bone in the form of grease and marrow (e.g., Binford 1978; Binford 1981; Hockett and Ferreira Bicho 2000; Lupo 2001; Lupo and Schmitt 1997; Madrigal and Capaldo 1999; Morin 2007; Outram 2001; Pickering and Egeland 2006; Schmitt et al. 2004).

The method used to transform animals from their raw state into food largely determines the nutritional value of the bone waste when deposited and its attractiveness to scavengers (e.g., Lupo 1995; Speth 2000; Ugan 2010). Bone grease is frequently located in the portions of bone that are the least dense (Binford 1978; Blumenschine and Marean 1993; Lyman 1985, 1992; Lyman 1994; Marean and Spencer 1991; Marean, et al. 1992), and scavengers are more likely to destroy these portions if the grease was not previously extracted using relatively intensive wet-cooking processes (Hudson 1993; Kent 1993; Lupo 1995; Lupo and Schmitt 1997; Speth 2000; Ugan 2010).

Whether culinary processing methods focusing on bone fat are practiced will depend on the animal and the relative value of this resource to an individual forager (Fisher and Johnson submitted; Outram 2004; Ugan 2005; Wandsnider 1997). The quantity of fat in the form of bone grease and marrow varies between taxa, individuals within a taxon, and body portions within an individual. Leporids, for example, contain relatively low fat content compared with other game animals, and it is expected that fat extraction from the skeletal component would be minimal as long as other fat resources are widely available (Fisher and Johnson submitted). In artiodactyls and other large game, the meat of long bones may be roasted and the marrow removed from the cavities, while portions may be boiled to extract the nutritional benefits that are otherwise difficult to obtain (e.g., Lupo 1995). However, young artiodactyls have much lower fat content than more mature individuals (e.g., Anderson and Wallmo 1984; Shackleton 1985; Speth and Spielmann 1983; Wandsnider 1997), and processing methods may follow accordingly.

In addition to the variation in bone fat among individual animals, the method used for preparing animal resources will partly depend on the resources available to the processor. Individuals with greater access to alternative resources are expected to process less intensively, resulting in potentially greater levels of carnivore ravaging and bone destruction. Since access to animal resources varies depending on both site location and temporal fluctuations in resource availability, culinary processing methods and resulting levels of attrition are expected to be context-dependent.

If culinary processing is dependent on the relative net returns from an animal resource and alternative resources, and if this in turn results in differential attrition of the various taxa involved, it is expected that density-mediated destruction would have a significant impact on relative taxonomic frequencies. This may be investigated by identifying the variance in attrition among different animal resources and correlating this with taxonomic diversity measures. To date, the only evaluation of the relationship between culinary processing, density-mediated destruction, and taxonomic abundances was conducted by Ugan (2005, 2010), although others have made informal reference to the fact that lower survivorship of smaller mammals likely impacts relative abundances (e.g., Lyon 1970). Using Parowan Valley assemblages from the eastern Great Basin, Ugan (2005) found that density-mediated destruction varied between occupational units. Furthermore, he argues that the degree of attrition may impact a number of other analyses. For example, a higher ratio of adult to juvenile individuals may be present if attrition had a greater impact on the less dense, immature skeletal remains. However, he found that density meditated destruction had no impact on the Artiodactyl Index (a common taxonomic measure of relative abundance of large to small game; see Section 3.5) in the assemblages he studied, even though the degree of destruction varied among artiodactyl assemblages through time.

3.2 Analyses

3.2.1 Density-mediated Destruction

Here, I evaluate the possibilities of density-mediated destruction for medium-sized artiodactyls (*Ovis*, *Odocoileus*, and *Antilocapra*) and for *Sylvilagus*. These taxa were chosen based on their relatively high abundances at the site, the availability of bone density data, and their frequent use in constructing the Artiodactyl Index. I aggregated all medium-bodied artiodactyl species into a single category since some elements, such as the ribs and vertebrae, cannot be identified to species. While minor morphological differences exist between the three artiodactyl species present at the site, intertaxonomic variability in density values between artiodactyl taxa appear to be relatively minimal (Lam, et al. 1999).

Regression is used to compare volume density values and skeletal part frequency. I use three different sets of density values here, depending on the quality of the data and the scan sites available. The density values for sheep provided by Lyman (1984) are used as a proxy for all artiodactyl skeletal parts with the exception of selected long bone scan sites. More recent work has demonstrated methodological problems in Lyman's original study for estimating cross-sectional area for bone sections with marrow cavities, and I use the corrected values for limb bones provided by Lam et al. (1998). Since some skeletal parts of sheep were not included in these two analyses, values for deer (Lyman 1984) are used to supplement the missing values. Null values are removed from analysis as it cannot be determined whether they represent real absences in the original population or a result of destructive forces (Lam and Pearson 2004).

Values for *Sylvilagus floridanus* (Pavao and Stahl 1999) are used as a proxy for *S. audubonii* and *S. nuttallii*, the two species present at Five Finger Ridge. Unlike the artiodactyls, element part representation for *Sylvilagus* may be affected by screening biases, and I have removed the caudal vertebrae, sternabrae, ribs, astragalus, metapodials, and phalanges from this analysis (Shaffer 1992; Shaffer and Sanchez 1994).

Standardized number of identified specimens (NNISP) is used as the measure of skeletal abundance. This measure is computed by dividing the number of identified specimens (NISP) for each element by the number of times the element is represented in a body. This avoids aggregation issues when computing minimum number of elements (MNE) at stratigraphically complex sites like Five Finger Ridge. It has been established that NISP is a strong predictor of MNE due to statistical sampling (Grayson and Frey 2004).

To determine if such a relationship is present in this assemblage, I performed a regression analysis between MNE values and NISP. MNE values for adult *Ovis* and *Odocoileus* were determined for the floor and fill of each structure and activity area by counting the number of redundant element portions while taking into account age and side (Appendix B). Estimated MNE values for *Sylvilagus* were computed for the site as a whole using the most common portion of each sided element.

There is a strong relationship between the element NISP and MNE for the site-wide assemblage (*Odocoileus* $r^2 = .79$, $p < .001$; *Ovis* $r^2 = .88$, $p < .001$; *Sylvilagus* $r^2 = .95$, $p < .001$). The only outliers present are the phalanges for both artiodactyl species, which have much greater MNE:NISP ratios than the remaining elements. This is likely due to an analytical bias, as fragmented phalanges can still frequently be identified to element and taxon. With the significantly positive relationship between MNE and NISP, density-mediated destruction can be evaluated using NNISP values.

The relationship between artiodactyl NNISP for the site-wide assemblage and volume density is significantly positive for artiodactyls as a whole ($r^2 = .42$, $p < .001$). The relationship for *Sylvilagus* is marginally insignificant ($r^2 = .08$, $p = .07$), with a single outlier (SP2=scapular neck; when removed, $r^2 = .14$, $p = .019$). This suggests that the rate of destruction based on bone density alone is a strong predictor for NNISP for artiodactyls but much less so for *Sylvilagus*.

As previously discussed, attrition may vary within the site due to differences in culinary processing and the nature of deposition between individual contexts. To evaluate the variability in attrition, the same relationship that I explored for the site-wide assemblage using volume density and NNISP values was explored for individual proveniences. I restricted the analysis to proveniences with artiodactyl sample sizes (NISP) of greater than thirty. Since this removes most floor deposits from the analysis, I also evaluated the relationship for the aggregated floor assemblages to provide a general comparison with the remainder of the proveniences.

There is considerable variability in the degree to which density-mediated destruction explains skeletal part frequencies for both artiodactyls and *Sylvilagus* within individual contexts (Table 3.1). However, sample size may be driving this variability; it is expected that a greater richness of scan sites in larger assemblages may result in higher coefficient of determination values and higher significance values. To determine whether this is the case, I compared NISP values with significant ($p < .05$) coefficient of determination values. There is a negative relationship for the artiodactyl assemblages ($r^2 = .34$, $p = .005$; Figure 3.1), indicating that contexts with larger artiodactyl assemblages have lower levels of density-mediated destruction (i.e., these assemblages may be large because of the lower attrition rates). For *Sylvilagus*, there is no significant relationship between strength of the relationship and sample size ($r^2 < .01$, $p = .96$). However, it is clear that the contexts with insignificant levels of attrition tend to have relatively low sample sizes (Figure 3.2).

Context-driven differences in attrition between the two sets of taxa may be due to culinary processing or to depositional differences. If artiodactyls and cottontail rabbits were prepared distinctly as food resources in ways that would differentially impact their survivorship in the archaeological record, I expect that levels of attrition should not co-vary between the two taxa. On the other hand, if variability in attrition between site contexts is due to other factors, such as depositional rate, the levels of attrition for the two taxa should correspond with one another. When I compared the coefficient of determination for artiodactyls and *Sylvilagus*, I found no significant relationship (Figure 3.3), indicating that destructive forces are working independently on the two sets of taxa. Using an arbitrary cutoff of $r^2 > .20$, there are numerous contexts that follow the site-wide pattern where attrition is relatively high for artiodactyls but not *Sylvilagus*. However, three contexts (fill of Pithouse 61, Activity Area 9, and Activity Area 13) have the opposite pattern, where the level of attrition is high for *Sylvilagus* but not artiodactyls. In only one case (Pithouse 29 Fill) is attrition high for both taxa.

3.2.2 Carnivore Marks among Site Contexts

Taken alone, the differing levels of attrition found between cottontail rabbits and artiodactyls is potentially indicative of the interrelationship between carnivore ravaging and culinary processing, and not depositional differences. This may be supported by evaluating signatures of carnivore scavenging, with the expectation that assemblages with high level of density-mediated destruction should have a larger number of carnivore marks. I use chi-square analysis to identify those artiodactyl and *Sylvilagus* assemblages that have significantly higher levels of carnivore ravaging. Since adjusted residuals are a continuous variable, these may be compared with the coefficient of determination (r^2) for attrition to evaluate whether density-mediated destruction was primarily a result of carnivore ravaging.

There is an uneven distribution of carnivore marks among the artiodactyl and *Sylvilagus* assemblages (artiodactyl $\chi^2 = 53.78$, $p < .001$; *Sylvilagus* $\chi^2 = 454.1$, $p < .001$; Table 3.2). When I compared the adjusted residuals for the presence of carnivore marks with the coefficient of determination for attrition, I found no relationship for artiodactyls ($r^2 = .05$, $p = .33$; Figure 3.4). In contrast, there is a relationship for *Sylvilagus* ($r^2 = .51$, $p = .009$; Figure 3.5), although the relationship is heteroscedastic.

Since carnivore access to skeletal remains may be determined by depositional contexts, I also evaluated whether the frequency of carnivore marks differed between occupational surfaces and fill. For both taxa, there is a significantly higher frequency of carnivore markers in the fill (artiodactyl $\chi^2 = 6.89$, $p = .009$; *Sylvilagus* $\chi^2 = 47.87$, $p < .001$; Table 3.3). This suggests that carnivores had less access to the floors, possible the result of fill being deposited on occupation surfaces shortly after abandonment.

3.2.3 Carnivore Marks among Skeletal Parts

To explore the relationship between carnivore ravaging and density-mediated destruction further, I turn to skeletal part fat indices to evaluate whether there is a relationship between the distribution of carnivore markers among skeletal parts and their fat utility. It is expected that the frequency of carnivore marks will correspond with bone grease volume if skeletal parts were not subjected to grease processing.

Due to the small sample size of specimens with carnivore marks among individual proveniences, I analyzed the distribution of such marks among skeletal parts using the site-wide artiodactyl assemblage. Carnivore markers are non-randomly distributed among artiodactyl skeletal parts ($\chi^2 = 92.03$, $p < .001$), with significantly higher frequencies of gnaw marks on the proximal femur, innominate, distal metapodials, proximal radius, and proximal tibia (Table 3.4).

To identify whether the distribution of carnivore marks corresponds with bone fat content, I turn to Binford's (1978) utility index values for caribou skeletal parts. These values are computed using bone grease volume, structural density, and skeletal part volume. I use his unstandardized grease values instead of the marrow index since the presence of hammerstone impact notches in the Five Finger Ridge assemblage indicates that the occupants of the site were actively removing marrow from the bone (Chapter 2), and this fat resource does not appear to have been available to scavengers. When the grease index values are compared with the adjusted residuals for the presence of carnivore markers among skeletal parts, there is a significant semi-log relationship ($r^2 = .29$, $p = .004$, Figure 3.6).

Carnivore marks are also non-randomly distributed among *Sylvilagus* elements ($\chi^2 = 231.24$, $p < .001$), with the femur, innominate, sacrum, and calcaneus having significantly higher frequency of marks (Table 3.5). Following Speth (2000), I use Binford's utility index values for caribou since comparable data on grease content that takes into account bone density and volume is not available for leporids. Since there is no reason to think that the absolute values for caribou correspond tightly to those for *Sylvilagus*, I have examined this relationship using a rank-order correlation coefficient, Spearman's rho. When I compared the adjusted residuals with fat volume for each element, I found a significant relationship (Spearman's rho = .41, $p = .04$, Figure 3.7).

3.2.4 Impacts on Taxonomic Diversity

The variability in density-mediated destruction between site contexts and both artiodactyls and *Sylvilagus* suggests my project goals for analyzing the spatial distribution of taxa and their skeletal parts may be biased by differential survivorship. The relatively high variability in attrition levels alone indicates that I cannot use the presence of skeletal parts to evaluate prehistoric sharing behaviors. I now turn to the impact that the varying degrees of bone attrition has on taxonomic diversity measures.

For this analysis, I use an Artiodactyl Index (AI) formed by dividing the frequency of artiodactyls with the total frequency of artiodactyls and *Sylvilagus* (∑Artiodactyls/(∑Artiodactyls+∑*Sylvilagus*)). I select this measure because it has become standard in addressing issues related to resource depression and diet breadth (e.g., Bird and O'Connell 2006; Broughton 2002; Lupo 2007), including those in the Fremont area (e.g., Janetski 1997; Janetski et al. 2000; Ugan 2005). As seen in Table 3.6, AI values vary considerably among proveniences, ranging from 0.10 (high *Sylvilagus* abundance) to 0.73 (high artiodactyl abundance). This variation is not dependent on sample size (r^2 = .04, p = .23).

Since I am interesting in the relationship between the AI values and differing rates of skeletal survivorship, I use the difference in attrition (Artiodactyl r^2 for attrition minus *Sylvilagus* r^2 for attrition) for site contexts with statistically significant relationships between volume density and skeletal part representation. There is a clear negative relationship between the two measures, indicating that AI values increase when density-mediated destruction has impacted *Sylvilagus* remains at a greater rate than artiodactyl remains (r^2 = .42, p = .02; Figure 3.8).

3.3 Discussion

I expected variation in density-mediated destruction between different locations within a site and between taxa as a result of different taphonomic histories. Exposure of faunal remains to destructive forces may depend partly on depositional rate, with bone that is buried more quickly having a higher likelihood of survivorship. Skeletal material that is exposed for longer periods of time is more likely to be attacked by scavengers, one of the most rapid destructive agents. However, the attractiveness of the bone debris will depend on culinary processing, which is expected to be variable across taxa and spatial contexts.

3.3.1 Culinary Processing

The degree that culinary processing removed grease from bone is argued to be correlated with bone attrition via carnivore scavenging (e.g., Lupo 1995; Speth 2000; Ugan 2010). Direct evidence of processing methods, such as butchering marks, impact marks, and burning, was presented in Chapter 2. Burned artiodactyl specimens are rare, and the distribution of burned specimens across the artiodactyl skeleton appears to be random (see Chapter 2). As such, heat-altered surfaces cannot be conclusively related to roasting activities and may have resulted from being exposed to fire after disposal. Cutmarks associated with filleting are common in the artiodactyl assemblage, and it may be that the meat was generally removed from bone prior to cooking. Subsequently, marrow was accessed from bone cavities using percussion.

As the most intensive processing method, grease extraction would have occurred after the meat and marrow were removed. Such processing is extensive, consisting of boiling bone parts that have been reduced in size for long durations of time. The reduction of bone portions may be identified by the presence of chop marks, and the long boiling periods in ceramic pots frequently produces characteristic “pot polish” on the edges of bone surfaces (e.g., Hurlbut 2000; White 1992). Both of these modifications may also be produced through a number of other cultural and natural processes, however. For example, chopping may be used to disarticulate joints of the skeleton, and polishing may occur as a result of trampling, alluvial actions, and other post-depositional forces (Turner and Turner 1999). Chop marks are rare in the Five Finger ridge assemblage, and the location of the marks corresponds best with disarticulation of anatomical portions and not the creation of pot-sized bone portions (Chapter 2). Pot polishing was not noted in the assemblage. The lack of cultural marks indicative of grease extraction matches my demonstration that the frequency of carnivore marks across the skeleton and bone grease values are correlated. Collectively, these data suggest that bone grease was not a major component of the Five Finger Ridge economy.

Unlike the situation for artiodactyls, evidence of culinary processing is limited to burning for the *Sylvilagus* assemblage. While the distribution of burning is more strongly patterned among the *Sylvilagus* remains compared to the artiodactyls (see Chapter 2), it is so infrequent that roasting does not appear to have been a common preparation method at the site. Considering the general lack of cutmarks of any sort and the low frequency of burning, it is likely that leporid meat was stewed along with the bone. Since the removal of nutrients locked inside of bone is largely a function of cooking time, it is possible that the occupants of Five Finger Ridge stewed rabbits for limited enough time that carnivores were still attracted to the remains. Indeed, I found that rapid stewing of jackrabbits occurred at Antelope Cave, a Virgin Anasazi dry cave site with excellent preservation located in northern Arizona (Fisher and Johnson submitted). Although stewing cannot be conclusively identified at Five Finger

Ridge, it is clear that carnivores were scavenging skeletal parts with the highest grease content, and were responsible for the variable rates of attrition among site contexts.

Since bone grease does not appear to have been removed from the artiodactyl or *Sylvilagus* remains, the differences in bone attrition between the two taxa does not appear to be a function of culinary processing.

3.3.2 Depositional Contexts

Depositional agents and rates may be responsible for some of the differences in attrition across proveniences. Two general depositional contexts are present in the Five Finger Ridge site: occupation surfaces (e.g., floors of structures) and fill. The floor assemblages at Five Finger Ridge are characterized by relatively small sample sizes, which may be expected considering that these are occupational surfaces that would have been actively maintained. Large debris may have been frequently cleaned from the floor, resulting in lower frequencies of artiodactyls compared to smaller animals. If this were the case, then skeletal part representation should be determined by specimen size and not bone density. Yet density-mediated destruction was found to be significant among artiodactyls in the aggregated floor assemblage, and, as a result, cultural maintenance of floors is unlikely the cause of these small sample sizes.

Taken alone, the high rates of attrition among artiodactyls from floor contexts could indicate that the remains were generally exposed for long enough periods of time after abandonment that low density skeletal parts were removed through attrition by carnivore scavenging. However, this is clearly an oversimplification considering the low rates of density-mediated destruction for *Sylvilagus* and the lower frequency of carnivore markers in the aggregated floor assemblage. Considering that carnivores frequently remove faunal remains from their original context and redeposit them elsewhere (e.g., Kent 1981; Marean, et al. 1992; Ugan 2010), it may be that domestic dogs and other scavengers removed the highest utility remains to consume them elsewhere. Presumably, these remains are the artiodactyl skeletal parts that have low density values. This behavior would result in low carnivore mark frequencies among structure floors for both taxa, the high rates of attrition for the taxon with the highest grease volumes, and possibly the lower rates of attrition in some fill contexts if the scavengers were redepositing remains in abandoned areas (e.g., Kent 1981).

3.3.3 Impact on the Artiodactyl Index

Regardless of how the differences in density-mediated destruction patterns are explained, it is clear that the level of attrition has an impact on the Artiodactyl Index. This noteworthy finding suggests that previous research using this index to identify temporal changes in resource use may need to be re-evaluated. This is especially true if skeletal survivorship is correlated with time.

There are a number of methods that may be employed to identify differences in taxonomic abundances when density-mediated destruction has variably impacted the taxa analyzed. First, one may use only those contexts in which density-mediated destruction was minimal for all taxa considered. This would allow for the identification of intra-site differences in taxonomic abundances, and to form an estimate of the site-wide assemblage if foraging behaviors are assumed to have been constant between households. However, there are likely real spatial differences in taxonomic representation that result from differences in individual foraging decisions and spatial organization. Hunting and gathering of animal resources differ between the sexes (e.g., Bird 1999; Hawkes 1996), between individuals within a sex (e.g., Smith et al. 2003), and within a single individual's life-history (e.g., Bird and Bliege Bird 2000; Kaplan et al. 2000). Furthermore, daily consumption may occur within some site contexts while feasting and similar events may be restricted to other locations (e.g., Hockett 1998; Potter and Ortman 2002). It may also be critical to evaluate why some assemblages appear to be unaffected by density-mediated destruction, as such assemblages may not be representative of foraging behaviors for the site as a whole.

A second option is to correct for density-mediated destruction by computing AI using anatomical portions with an even distribution of high density portions (Stiner 2000). However, to do so would require that the representation of anatomical portions among assemblages is not influenced by other factors, such as selective transportation and deposition of skeletal parts. Transportation of anatomical portions is determined by a wide range of factors, including distance from a kill and the number of individuals in a hunting party (e.g., Bartram 1993; Lupo 2006), and these will vary between sites and through time (e.g., Broughton 1994; Nagaoka 2005). Large game are also shared based on a number of motivations by the recipient and the donor, including kin selection, costly signaling, reciprocity, and scrounging (Allen-Arave et al. 2008; Bliege Bird et al. 2002; Bliege Bird et al. 2001; Gintis et al. 2001; Gurven 2004a, b; Gurven et al. 2000; Hames and McCabe 2007; Hawkes et al. 2001a, b; Lupo and Schmitt 2004; Patton 2005; Waguespack 2002).

Furthermore, the households at Five Finger Ridge were not occupied simultaneously, and it is possible that temporal fluctuations in local faunal abundances are also determining the taxonomic frequencies seen between households.

3.4 Conclusion

3.4.1 Implications for the use of the Artiodactyl Index

A large number of studies have used the Artiodactyl Index to evaluate the diet breadth model by using the relative taxonomic abundances at sites to determine the local population levels of artiodactyls by assuming that foraging decisions are based on optimal foraging models. This research is critical for understanding human-environment interactions, such as the impact of climate-induced resource fluctuations and overhunting by prehistoric peoples. The potential relationship between culinary processing and both the relative abundances of alternative resources to process and attrition rates demand the evaluation of density-mediated destruction and its causes for individual sites and site contexts. Although the cause for the variability in attrition is largely inconclusive, the data at Five Finger Ridge illustrates that this is a critical step for understanding the variability in the Artiodactyl Index.

The relationship between attrition and taxonomic abundances from Five Finger Ridge proved to be different from that found by Ugan (2005) for Evans Mound and Median Village, although it is not clear what is driving this difference. At the latter two sites, density-mediated destruction for artiodactyls and lagomorphs were found to be strongly correlated, and the level of attrition in artiodactyls correlated well with the Artiodactyl Index. Ugan ultimately argues that the variation in age-structure, AI values, and density-mediated destruction may be related to climatic changes during the occupation of the two sites. At Five Finger Ridge, density-mediated destruction of artiodactyls and *Sylvilagus* do not correspond with one another, and there appears to be a relationship between the absolute difference in attrition and the AI measure. Unfortunately, the temporal designation of structure fill is currently unavailable, and cannot be correlated with general environmental conditions at this time. Nonetheless, the fact that both studies have demonstrated relationships between attrition and relative taxonomic abundances is the critical lesson here.

3.4.2 Implications for Detecting Costly Signaling at Five Finger Ridge

The goal of my research was to triangulate the spatial patterns of faunal remains with temporal patterns in resource abundances, with the expectation that the increased signaling value of prey that become increasingly rare on the landscape will be shared widely and indiscriminately among households. To do so, I set forth a series of predictions using the spatial distribution of faunal remains to identify differences in foraging strategies and sharing among individuals. It is clear from the analysis presented in this chapter that the measures used to identify household patterns—taxonomic richness and evenness combined with skeletal part richness and evenness—have both been significantly impacted by complex taphonomic histories at Five Finger Ridge.

Such histories cannot simply be undone to view the original deposit representing human actions. Although skeletal part attrition may be circumvented through the use of anatomical units, the predictions for skeletal part evenness and richness cannot be tested using these units as it would significantly reduce the number of categories used. Even if this were not the case, changing the analytical unit would only account for missing, low density portions of the skeleton; it would not be able to circumvent carnivore movement of faunal remains among site contexts, which likely occurred at Five Finger Ridge. The predictions using household assemblages await a site with fauna that have not been so variably impacted by taphonomic processes.

In the following two chapters, I will shift focus from the spatial distribution of fauna to the identification of temporal changes in taxonomic abundances at Five Finger Ridge. Although I will not be able to use sharing as an independent test for costly signaling, I may still be able to identify possible signaling species for the site-wide assemblage using demographics, relative taxonomic abundances, and indicators of transport, including stable isotope analysis.

Tables

Table 3.1. Artiodactyl and *Sylvilagus* skeletal part attrition and number of identified specimens (NISP) in Five Finger Ridge contexts.

Provenience	Artiodactyl			*Sylvilagus*		
	NISP	Attrition (NNISP:VD)		NISP	Attrition (LOGNNISP:VD)	
		r^2	sign.		r^2	sign.
Floors, combined	475	0.39	0.00	1354	0.01	0.55
PH 43 Floor	24	---	---	76	0.00	0.97
PH 3 Fill	158	0.02	0.29	548	0.06	0.12
PH 9 Fill	30	0.01	0.59	27	0.05	0.15
PH 14 Fill	32	0.30	0.01	16	0.01	0.80
PH 17 Fill	39	0.01	0.55	121	0.13	0.05
PH 20 Fill	32	0.01	0.71	85	0.03	0.34
PH 22 Fill	115	0.10	0.01	323	0.05	0.17
PH 26 Fill	171	0.03	0.22	340	0.09	0.07
PH 28 Fill	176	0.00	0.91	204	0.06	0.16
PH 29 Fill	101	0.12	0.02	154	0.41	0.00
PH 30 Fill	104	0.29	0.00	125	0.02	0.50
PH 33 Fill	46	0.06	0.17	188	0.09	0.07
PH 36 Fill	53	0.31	0.00	236	0.05	0.15
PH 38 Fill	45	0.55	0.00	246	0.12	0.03
PH 43 Fill	32	---	---	233	0.10	0.05
PH 45 Fill	32	---	---	55	0.06	0.17
PH 48 Fill	50	0.17	0.24	80	0.12	0.07
PH 56 Fill	98	0.18	0.00	414	0.09	0.07
PH 57 Fill	83	0.07	0.04	292	0.15	0.02
PH 60 Fill	79	0.13	0.04	33	0.01	0.64
PH 61 Fill	239	0.02	0.21	419	0.33	0.00
PH 67 Fill	25	---	---	65	0.22	0.01
PH 70 Fill	46	0.12	0.04	69	0.05	0.19
PH 75 Fill	66	0.18	0.00	99	0.07	0.19
PH 79 Fill	66	0.01	0.52	160	0.03	0.30
SS 4 Fill	26	0.18	0.05	67	0.06	0.18
SPS 21 Fill	61	0.17	0.00	62	0.01	0.65
SPS 39 Fill	15	---	---	70	0.04	0.30
SPS 62 Floor	61	0.22	0.00	48	0.02	0.52
AA 08 Fill	101	0.01	0.43	38	0.05	0.19
AA 09 Fill	274	0.06	0.03	393	0.33	0.00
AA13 Floor	15	---	---	42	0.02	0.57
AA 13 Fill	41	---	---	146	0.23	0.00
AA 24 Fill	94	0.04	0.16	190	0.10	0.05
AA 28 Fill	156	0.09	0.01	219	0.14	0.02
AA C Fill	11	---	---	96	0.39	0.00

Table 3.2. Frequency of carnivore markers (NISP) and chi-square adjusted residuals for marker presence in Five Finger Ridge site contexts. *: p < .001; **: p < .01; ***: p < .05.

Provenience	Artiodactyl			*Sylvilagus*		
	Absent	Present	Adj. Res.	Absent	Present	Adj. Res.
AA 08 Fill	76	20	+3.17**	9	29	+2.39***
AA 09 Fill	233	41	+2.26***	54	339	+1.52
AA 13 Fill	36	5	+0.26	32	114	+4.05*
AA 13 Floor	--	--	--	17	25	+5.95*
AA 24 Fill	86	9	-0.46	27	163	+1.24
AA 28 Fill	143	13	-1.07	43	176	+3.91*
AA C Fill	--	--	--	20	76	+2.94**
PH 3 Fill	145	13	-1.12	3	545	-8.38*
SS 4 Fill	26	0	-1.79	4	63	-1.40
PH 9 Fill	27	3	-0.16	1	26	-1.26
PH 14 Fill	32	0	-1.99	2	14	+0.14
PH 17 Fill	39	0	-2.20***	5	116	-2.54***
PH 20 Fill	31	1	-1.42	0	85	-3.33**
SPS 21 Fill	58	13	+2.02***	20	42	+5.20*
PH 22 Fill	100	15	+0.75	62	261	+4.54*
PH 26 Fill	86	18	+2.13***	70	270	+5.50*
PH 28 Fill	149	28	+2.16***	10	194	-2.97**
PH 29 Fill	87	12	+0.39	46	108	+7.31*
PH 30 Fill	95	9	-0.76	10	115	-1.21
PH 33 Fill	37	9	+1.90	25	163	+0.84
PH 36 Fill	52	1	-2.13***	19	217	-1.65
PH 38 Fill	40	5	+0.04	11	235	-3.49*
SPS 39 Fill	--	--	--	13	57	+1.90
PH 43 Fill	35	2	-1.08	2	231	-5.16*
PH 43 Floor	--	--	--	2	74	-2.42***
PH 45 Fill	32	2	-0.95	1	54	-2.25***
PH 48 Fill	50	0	-2.50***	3	77	-2.17***
PH 56 Fill	90	9	-0.60	28	386	-3.07**
PH 57 Fill	77	6	-1.10	35	257	+0.33
PH 60 Fill	74	5	-1.33	0	33	-2.07***
PH 61 Fill	211	28	+0.41	92	327	+7.06*
SPS 62 Floor	53	8	+0.56	2	46	-1.58
PH 67 Fill	--	--	--	5	60	-0.94
PH 70 Fill	39	7	+0.94	2	67	-2.23***
PH 75 Fill	63	5	-0.96	4	95	-2.32***
PH 79 Fill	63	3	-1.68	2	158	-4.10*

Table 3.3. Frequency (NISP) of carnivore marks in site fill and floor contexts for *Sylvilagus* and artiodactyls. *: p < .001; **: p < .01.

		Present	Absent	Adj. Res. (Present)
Sylvilagus	Fill	771	5862	+6.92*
	Floor	126	1888	-6.92*
Artiodactyl	Fill	340	2722	+2.62**
	Floor	58	684	-2.62**

Table 3.4. Frequency of carnivore marks (NISP) among artiodactyl skeletal elements with chi-square adjusted residuals for presence of marks and unstandardized grease index values (from Binford 1978). *: p < .001; **: p < .01; ***: p < .05.

Skeletal Part	Carnivore Absent	Carnivore Present	Adj. Res. (Present)	Grease Index
Mandible	73	6	-1.37	2.65
Atlas	27	6	+0.97	2.78
Axis	19	2	-0.43	2.74
Cervical	97	10	-1.04	2.60
Thoracic	116	23	+1.44	2.60
Lumbar	121	20	+0.58	3.14
Rib	373	25	-4.20*	1.59
Sternum	5	0	-0.85	5.51
Scapula	68	1	-2.84**	1.63
Humerus, Prox	8	1	-0.14	5.90
Humerus, Dist	60	9	+0.11	15.99
Radius/Ulna, Prox	73	20	+2.64**	7.96
Radius/Ulna, Dist	21	6	+1.51	6.93
Metacarpal, Prox	66	8	-0.48	3.54
Metacarpal, Dist	35	10	+1.96***	9.00
Innominate	118	39	+4.79*	6.20
Femur, Prox	12	6	+2.66**	5.70
Femur, Dist	20	5	+1.12	21.19
Tibia, Prox	12	5	+2.09***	14.70
Tibia, Dist	68	7	-0.87	5.52
Astragalus	50	6	-0.43	6.88
Calcaneous	79	15	+1.00	9.95
Metatarsal, Prox	89	6	-1.89	3.79
Metatarsal, Dist	32	10	+2.21*	9.14
Phalanx, First	131	9	-2.28*	7.05
Phalanx, Second	83	15	+0.82	5.25
Phalanx, Third	70	8	-0.64	2.88

Table 3.5. Frequency (NISP) of carnivore marks among *Sylvilagus* skeletal elements with chi-square adjusted residuals for presence of marks and unstandardized grease index values (from Binford 1978). *: p < .001; **: p < .01; ***: p < .05.

Skeletal Part	Carnivore Absent	Carnivore Present	Adj. Res. (Present)	Grease Index
Mandible	621	63	-2.07***	2.65
Atlas	37	0	-2.21***	2.78
Axis	28	1	-1.38	2.74
Cervical	50	0	-2.57**	2.60
Thoracic	165	6	-3.35*	2.60
Lumbar	536	64	-0.76	3.14
Scapula	612	37	-4.95*	1.63
Humerus, Prox	186	12	-2.48***	5.90
Humerus, Dist	379	69	+2.59**	15.99
Radius/Ulna, Prox	427	55	-0.14	7.96
Radius/Ulna, Dist	143	5	-3.16**	6.93
Metacarpal, Prox	206	6	-4.06*	3.54
Metacarpal, Dist	167	0	-4.74*	9.00
Innominate	497	146	+9.25*	6.20
Femur, Prox	273	61	+3.90*	5.70
Femur, Dist	226	61	+5.21*	21.19
Tibia, Prox	214	43	+2.61**	14.70
Tibia, Dist	112	35	+4.67*	5.52
Astragalus	52	6	-0.30	6.88
Calcaneous	154	45	+4.92*	9.95
Metatarsal, Prox	312	38	-0.45	3.79
Metatarsal, Dist	153	0	-4.54*	9.14
Phalanx, First	199	9	-3.33*	7.05
Phalanx, Second	63	3	-1.80	5.25
Phalanx, Third	12	0	-1.26	2.88

Table 3.6. NISP and Artiodactyl Index values for Five Finger Ridge site contexts.

Provenience	**Artiodactyl NISP**	***Sylvilagus* NISP**	**Artiodactyl Index**
Floors	475	1354	0.26
AA 08 Fill	101	38	0.73
AA 13 Floor	15	42	0.26
AA 09 Fill	274	393	0.41
AA 13 Fill	41	146	0.22
AA 24 Fill	94	190	0.33
AA 28 Fill	156	219	0.42
AA C Fill	11	96	0.10
PH 3 Fill	158	548	0.22
SS 4 Fill	26	67	0.28
PH 9 Fill	30	27	0.53
PH 14 Fill	32	16	0.67
PH 17 Fill	39	121	0.24
PH 20 Fill	32	85	0.27
SPS 21 Fill	61	62	0.50
PH 22 Fill	115	323	0.26
PH 26 Fill	171	340	0.33
PH 28 Fill	176	204	0.46
PH 29 Fill	101	154	0.40
PH 30 Fill	104	125	0.45
PH 33 Fill	46	188	0.20
PH 36 Fill	53	236	0.18
PH 38 Fill	45	246	0.15
SPS 39 Fill	15	70	0.18
PH 43 Fill	32	233	0.12
PH 43 Floor	24	76	0.24
PH 45 Fill	32	55	0.37
PH 48 Fill	50	80	0.38
PH 56 Fill	98	414	0.19
PH 57 Fill	83	292	0.22
PH 60 Fill	79	33	0.71
PH 61 Fill	239	419	0.36
SPS 62 Floor	61	48	0.56
PH 67 Fill	25	65	0.28
PH 70 Fill	46	69	0.40
PH 75 Fill	66	99	0.40
PH 79 Fill	66	160	0.29

Figures

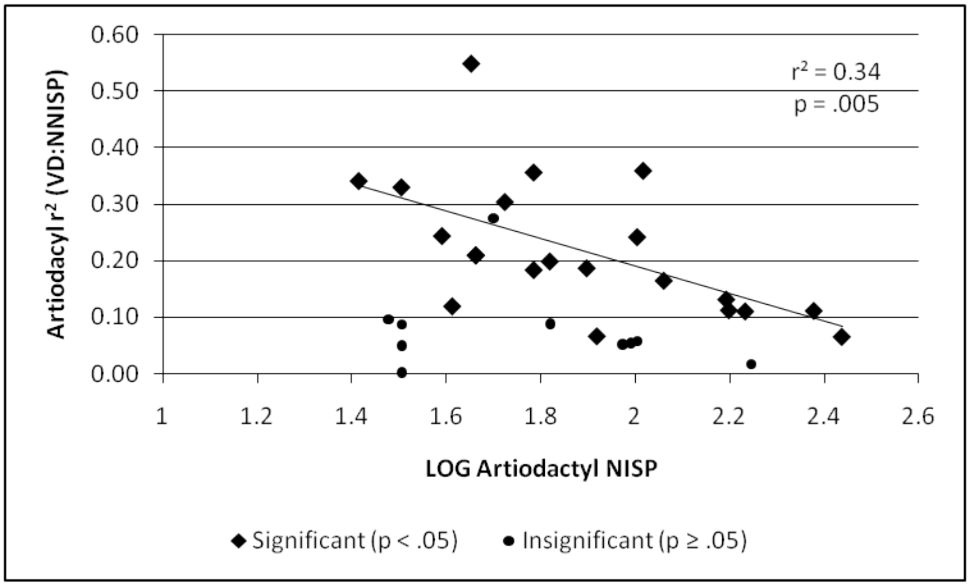


Figure 3.1. Relationship between coefficients of determination (VD vs. NNISP) and sample size (NISP) for artiodactyls.

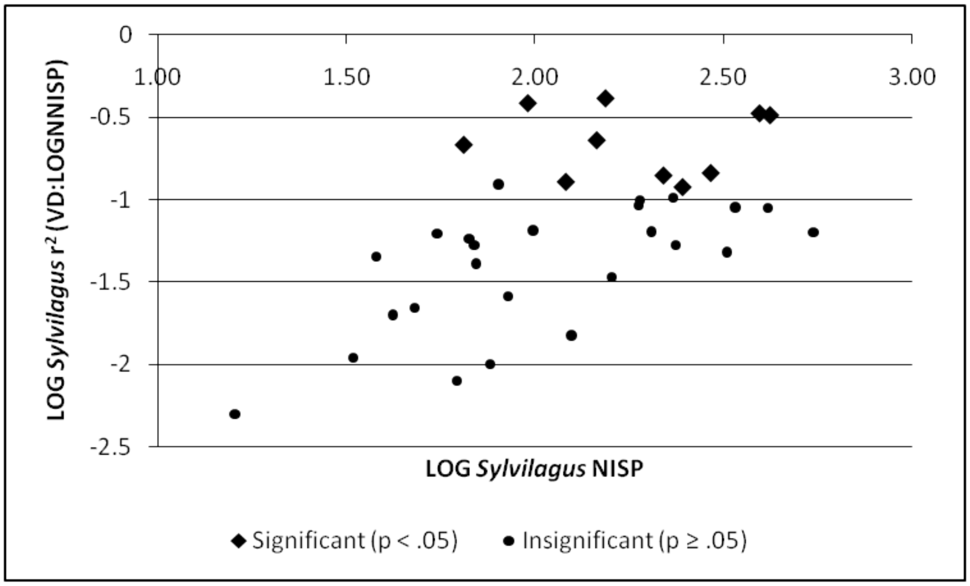


Figure 3.2. Relationship between coefficients of determination (VD vs. NNISP) and sample size (NISP) for *Sylvilagus*.

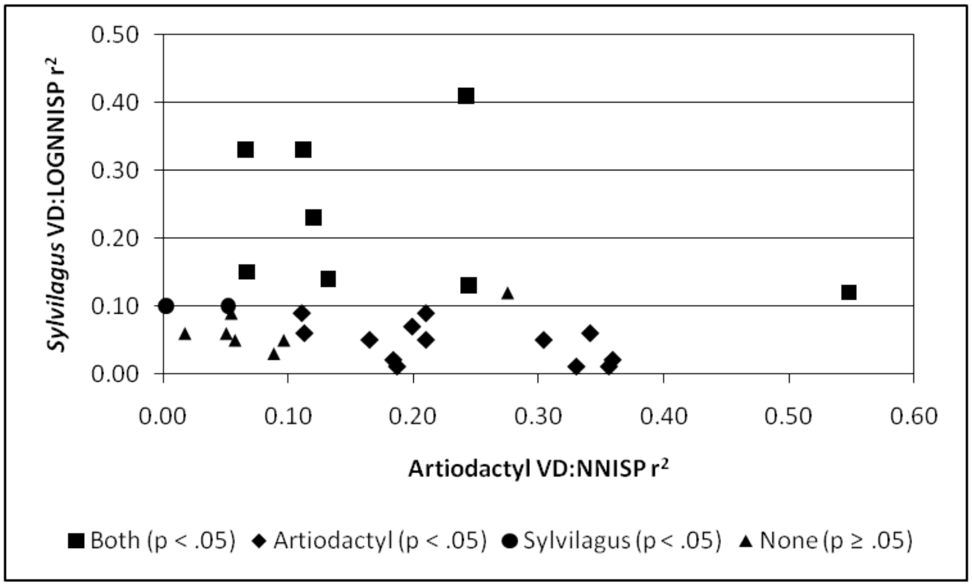


Figure 3.3. Relationship between coefficients of determination (VD vs. NNISP) for *Sylvilagus* and artiodactyls, separated by significance level ($p < .05$)

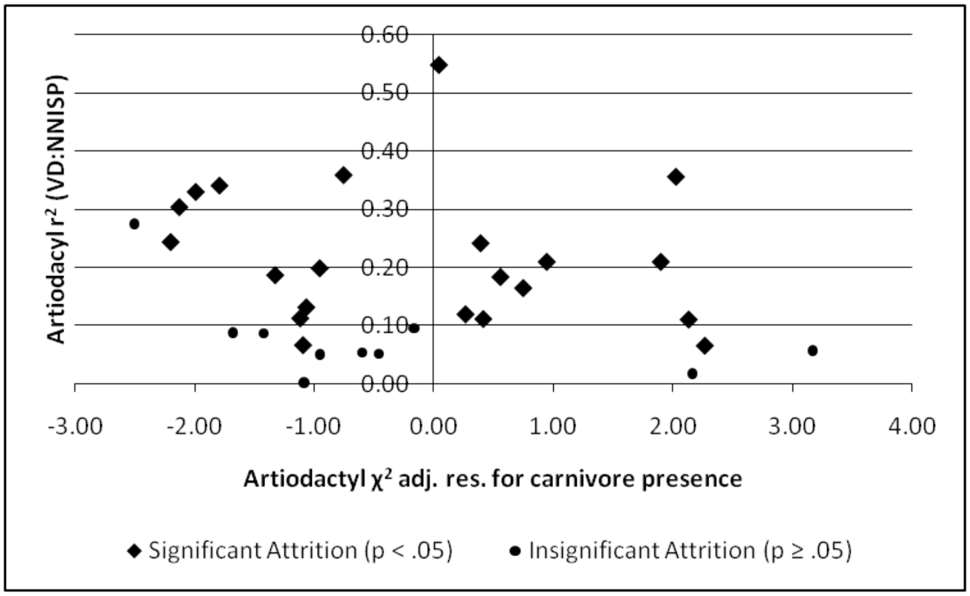


Figure 3.4. Relationship between artiodactyl attrition values and the frequency of carnivore marks among site contexts based on chi-square adjusted residuals for presence.

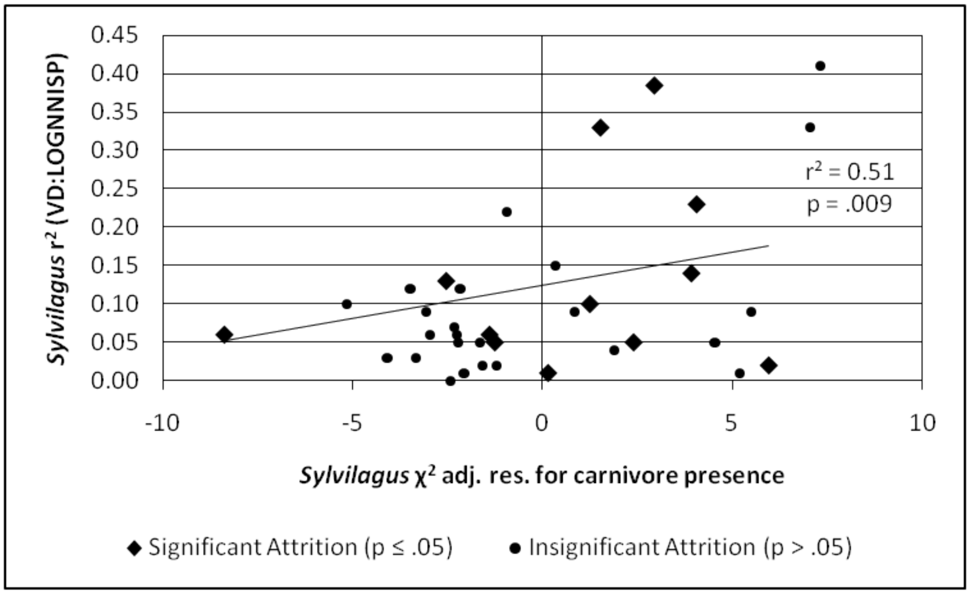


Figure 3.5. Relationship between *Sylvilagus* attrition values and the frequency of carnivore marks among site contexts based on chi-square adjusted residuals for presence.

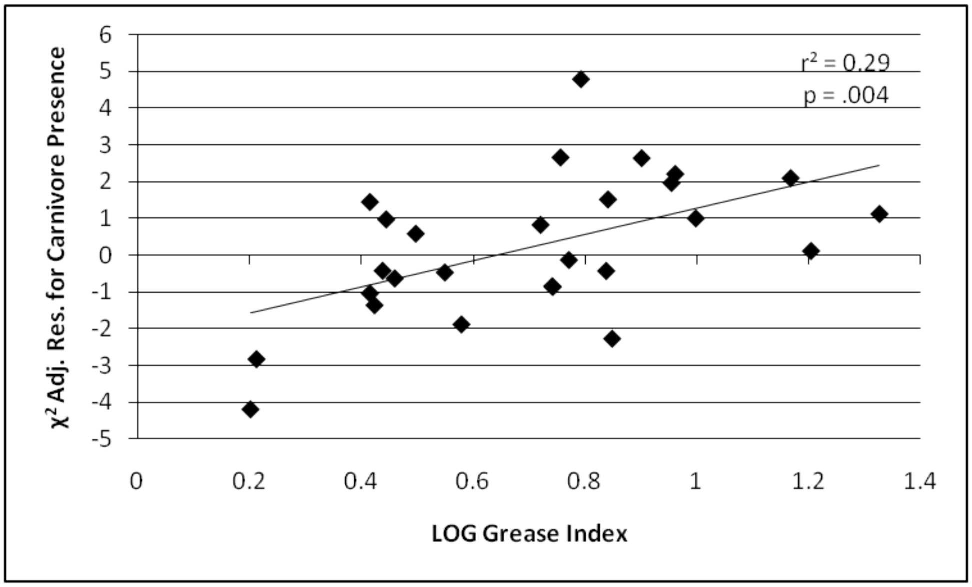


Figure 3.6. Relationship between the chi-square adjusted residuals for the presence of carnivore marks and the grease index for each artiodactyl skeletal part.

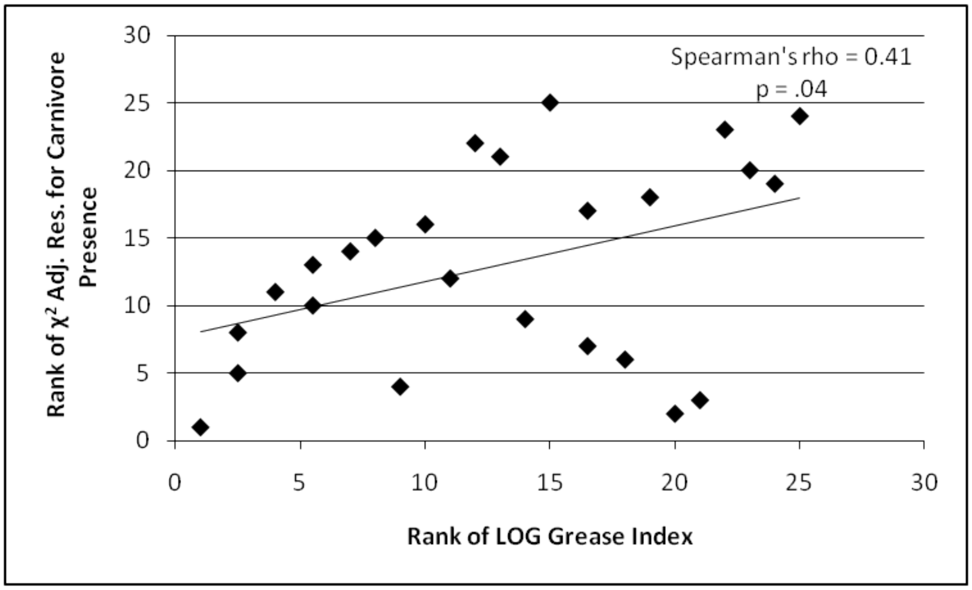


Figure 3.7. Rank-ordered relationship between the chi-square adjusted residuals for the presence of carnivore marks and the grease index for each Sylvilagus skeletal part.

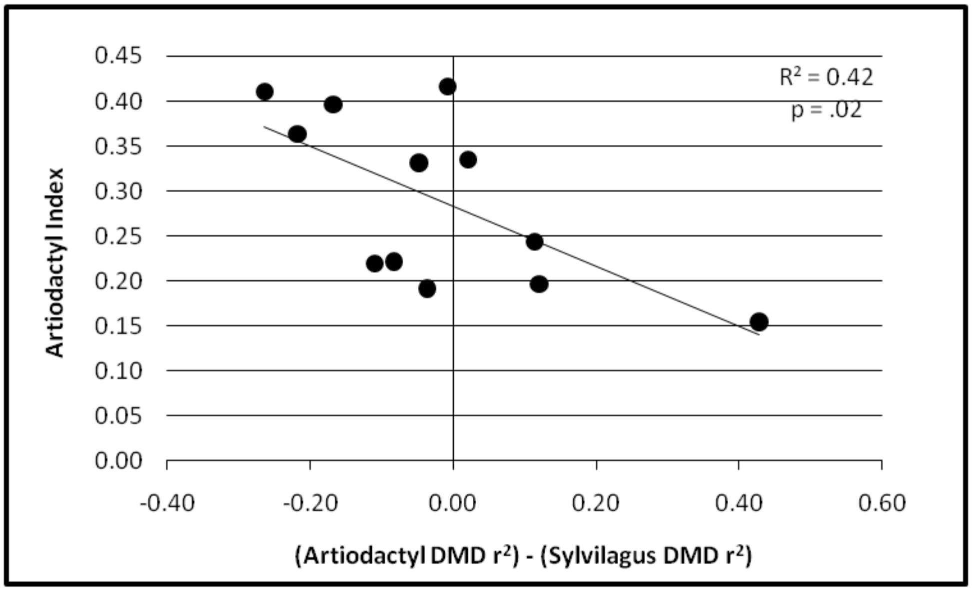


Figure 3.8. Relationship between the Artiodactyl Index and the difference in the degree of density-mediated destruction (r2) for the two taxa.

Chapter 4

ANIMAL EXPLOITATION

4.1 Introduction

My original goal for this research was to identify the kinds of animal resources targeted by signaling hunters, and whether these resources were subsequently distributed to others in the village according to different modes of sharing (reciprocity, scrounging, and signaling). In Chapter 3, I conducted a taphonomic analysis of the Five Finger Ridge assemblage to determine whether patterns in the relative frequency of skeletal parts and species in the Five Finger Ridge faunal assemblage are the result of non-human behavior. I discovered significant density-mediated attrition among skeletal remains between site contexts and animal taxa, greatly limiting the ability to identify behaviorally meaningful taxonomic and skeletal part diversity among households.

Here I attempt to bypass the detrimental impacts of intrasite taphonomic variability to evaluate what kinds of patterns of animal resource use and availability may be identified from the Five Finger Ridge assemblage. I will do so by identifying patterns of relative skeletal abundances, demographics, seasonality, and temporal relationships between taxa that collectively may be used to identify changing resource use through time. Ultimately, my goal is to understand the nature of these changes in light of human-environment interactions resulting from the combined impact of hunting pressure and climate change.

Culturally-induced resource depression has been documented in a number of locations in western North America and beyond (e.g., Byers and Broughton 2004; Grayson

2001; Lupo and Schmitt 1997; Ugan 2005). As discussed briefly in Chapter 1, large-bodied prey are more prone to overhunting due to their longer gestation periods, reduced number of offspring, prolonged maturation rates, and larger required ranges (e.g., Broughton 2002). Hunting pressure that has led to reduced local prey population levels has been shown to result in increased diet breadth, generally shown archaeologically by an increase in taxonomic richness with smaller prey increasingly dominating the diet through time.

In the previous chapter, I demonstrated significant levels of variability in attrition between small (*Sylvilagus*) and large artiodactyls game. One of the most critical lessons from this study is that the relative abundances of different kinds of animals may not represent foraging decisions but may instead be a reflection of the taphonomic history of each animal. However, there may be other ways that localized resource depression can be manifested in the archaeological record, including indicators that animals were being acquired from increasingly distant locations and changing demographics of the animal populations being exploited.

Not all changes in the relative abundances of different taxa are directly related to foraging decisions, however. As I discuss below, some taxa identified in the Five Finger Ridge assemblage may be indicators of climate change occurring at the end of the Fremont period, when a shift occurred from warm temperatures with monsoonal precipitation to cooler temperatures dominated by Pacific winter storms.

4.2 Relative Skeletal Abundances

Various measures of relative skeletal abundances (RSA) have been developed to infer site function and bone transportation, with the general assumption that low-quality portions of prey will more often be discarded at kill-sites while high-utility portions are transported to the residential base (Bartram 1993; Binford 1978; Faith and Gordon 2007; Lupo 2001; Metcalfe and Jones 1988; O'Connell et al. 1990). Forming such inferences is complicated by variation in human behavior and the decisions made when foraging across a skeleton, as well as complications arising from post-depositional processes. In particular, carnivore ravaging, weathering, trampling, and other forces may selectively remove a portion of the faunal assemblage, resulting in equifinality with patterns produced by behavioral processes (Lam and Pearson 2005; Lyman 1984, 1985; Lyman 1994).

In the previous chapter, I discovered that attrition played a significant impact on the representation of various skeletal parts, although the degree of destruction varied greatly between different site contexts for unexplained reasons. This is problematic for evaluating resource use between households at Five Finger Ridge, as it is not possible to filter through the taphonomic effects to determine what animals and body parts were originally exploited by individual households. At most, skeletal part representation may be evaluated on a site-wide basis to identify general patterns of animal exploitation, such as transport decisions regarding which parts should be brought back to a residential base. The effects of density-mediated destruction may be circumvented in this larger sample by using anatomical body portions instead of individual skeletal element portions since each anatomical portion is equally represented by high density skeletal portions (Stiner 2002).

The goal here is to identify patterns of relative skeletal abundance between taxa and through time to determine how animals may have been transported and whether this changed through time. Only the artiodactyls are analyzed here as the small game, such as the leporids, are more likely to have been transported whole to the site and to have relative skeletal abundances that are variably impacted by a combination of fragmentation and screen recovery rates.

Broughton (1994), in his treatise on the artiodactyl resource depression in the San Francisco Bay region, used relative skeletal abundances to argue that large game were transported greater distances when local artiodactyl populations were depressed. However, the absence of change in RSA profiles does not necessarily imply lack of change in local resource populations. Hunters may continue to transport the same skeletal portions back to the residential base regardless of distance, depending on the size of the hunting party, the underlying motivation for hunting (e.g., signaling hunters may transport a larger portion of the carcass), and other variables (e.g., Bartram 1993; Lupo 2006). Issues in identifying transportation will be discussed further in Chapter 5. Here I limit the analysis to relative skeletal abundances to identify whether changes were indeed present within the Five Finger Ridge dataset.

Relative skeletal abundances are computed for anatomical regions using standardized number of identified specimen (NNISP) values. While Stiner (2002) uses MNE values, it has been demonstrated that the MNE values can be reliably predicted using NISP (Grayson and Frey 2004; Chapter 3). Here, I use the NISP values of each individual skeletal part, normed by the number of instances that part is found in the skeleton (NNISP). The values for the anatomical regions are the summed NNISP of the composite skeletal elements. I classified elements into anatomical region categories following Stiner (2002) with some exceptions. Antler and horn are included in the counts for head to increase the sample size. Stiner excludes teeth from the counts for the head due to the higher density of tooth enamel and dentine compared to bone. Here, I have used a separate category for teeth for comparison. Axial elements are limited to skeletal parts that can be identified to species, thereby excluding most vertebrae (exceptions being the atlas and axis) and all ribs. Due to the differences in body size and its likely impact on the exploitation of neonatal *Odocoileus*, these have been removed from analysis. I have also removed worked bone specimens from the assemblage since prehistoric curation of these elements may potentially inflate values, especially for metapodials (see Chapter 2). For graphical representation, I have converted the anatomical unit NNISP values to percentage values (%NNISP) by dividing each portion by the part with the highest abundance (anatomical part NNISP/maximum NNISP).

The site-wide RSA profiles for *Odocoileus hemionus*, *Ovis canadensis*, and *Antilocapra americana* are displayed in Figure 4.1. I calculated Shannon evenness values for the relative skeletal abundances of each taxon to provide a quantitative measure of relative skeletal abundance (Faith and Gordon 2007; Magurran 1988). The expectation is that taxa that were transported more completely back to Five Finger Ridge should be represented by a more even distribution of anatomical parts. *Odocoileus* has the highest evenness value (.843), followed by *Ovis* (.652) and *Antilocapra* (.545). The evenness value for *Odocoileus* is significantly different than both *Ovis* ($t = 4.68$, $df = 395$, $p < .001$) and *Antilocapra* ($t = 2.82$, df = 12, p = .02); the evenness values for *Ovis* and *Antilocapra* are not significantly different from each other.

I conducted a chi-square test to determine what anatomical parts are driving the differences in evenness between mountain sheep and deer (pronghorn excluded due to the small sample size). The differences are significant ($\chi^2 = 35.8$, $p < .001$), with deer represented by a significantly higher frequency of upper front limb and lower hind limb specimens, and fewer lower front limb specimens (Table 4.1). Considering that these portions have moderately high utility values (Binford 1978; Metcalfe and Jones 1988), the differences found in anatomical body parts do not appear to relate to selective transport of portions based on energetic value, although the significantly higher Shannon evenness value suggests that a larger portion of the deer was being transported.

Pronghorn have larger number of lower hind limb specimens than the other two artiodactyls, and significantly fewer lower front limb specimens. In general, this species is represented by a comparatively limited set of skeletal parts consisting of only the head, distal lower forelimb, distal lower hindlimb, and phalanges. These skeletal elements are of relatively low economic value (Binford 1978). Such a pattern is interesting considering that the most likely source of pronghorn would have been Sevier Valley, approximately 4.25 km to the east. If hunters were foraging across the skeleton on the basis of caloric returns, it is expected that they would have transported the high utility portions and not the skeletal elements that are found in the site assemblage. This suggests that transport decisions for *Antilocapra* may not have been based on body part utility but some other currency.

Temporal differences in the relative skeletal abundances for *Odocoileus* are presented in Figure 4.2. Anatomical part evenness decreased from Period 1 (e = .747) and Period 2A (e = .747) to Period 2B (e = .648), but the evenness values are not significantly different (Period 1-2B: t = .50, df = 42, p > .50). Due to the small sample sizes for the dated assemblages (Period 1 NISP = 55, Period 2A NISP = 54, Period 2B NISP = 71), chi-square analysis could not be conducted to determine whether there is a change in frequency of anatomical portions. Visual evaluation of the graph shows that most elements are equally represented among the temporal periods, although there may be a potential reduction in the relative abundances of deer head elements through time. This trend, however, would have resulted in significantly lower evenness values, which is not the case.

As with *Odocoileus*, skeletal part evenness values for *Ovis* appear to decrease from Period 1 (e = .736) and Period 2A (e = .741) to Period 2B (e = .672), but this change is not statistically significant (Period 1-2B: t = 1.29, df = 67, p = .20; Figure 4.3). Again, sample sizes for the three temporal units are too small to identify differences in the distribution of skeletal elements through time (Period 1 NISP = 86, Period 2A NISP = 24, Period 2B NISP = 78). Although there appears to be a greater number of head specimens and a lower number of lower hind limb specimens in Period 2A, this may be due to the smaller sample size present.

Since the RSA profiles for each of the medium-bodied artiodactyl species do not include specimens identified to unassigned artiodactyl, Figure 4.4 is provided to show the temporal changes in artiodactyls as a whole. This matches the findings for *Ovis* and *Odocoileus*, with an apparent decrease in the number of head and axial elements from Period 2A to Period 2B. Likewise, Shannon evenness values drop from Period 1 (e = .841) and

Periods 2A (e = .847) to 2B (e = .756), with the value for the last period being significantly lower than the previous two (Period 1-2B: t = 3.04, df = 166, $p < .005$; Period 2A-2B: t = 2.52, df = 83, $p < .02$).

I use a chi-square test to identify changes in the relative abundance of elements among temporal periods for the aggregated medium-bodied artiodactyls. There are significant differences among the three temporal units ($\chi^2 = 40.8$, $p < .001$). As can be seen in Table 4.2, Period 2B has significantly fewer axial elements and a greater number of lower hind limb elements. Furthermore, the adjusted residuals show that there is a trend among all of the elements through the three periods. The adjusted residuals for the head, teeth, axial, upper hind limb, and feet elements all decrease from Period 1 to Period 2B, while the upper and lower front limb and lower hind limb increase through time. This pattern, characterized by an increased abundance of high-utility skeletal portions through time, is suggestive of shifting transport costs that resulted in later hunters bringing back a smaller portion of the skeleton to Five Finger Ridge.

Lastly, the RSA profile for *Bison* is presented in Figure 4.5. The overall paucity of specimens (NISP = 32) in the whole assemblage is likely the result of selective transport of body parts from such a large-bodied animal. *Bison* are not likely to have been acquired in the vicinity of Five Finger Ridge, but may have been acquired in Sevier Valley a short distance to the east. Four specimens of bison recovered from floor contexts indicate that they were exploited during Periods 2A and 2B.

4.3 Demographics and Seasonality

Age mortality profiles of individual taxa provide a range of data regarding local hunting pressure and hunting methods, as well as seasonality for some species. If hunters are targeting prey for their size or energetic returns, they should focus on fully mature adults as they provide larger packages of meat with a higher ratio of fat to protein (Munro 2004). However, increased hunting pressure by predators will alter recruitment rates (Broughton 2002; Munro 2004; Ugan 2005), resulting in populations with a higher ratio of young animals. Thus resource depression may potentially result in assemblages with decreasing maximum age of adults and increasing dominance of young individuals. However, this is complicated by the fact that hunters do not necessary encounter prey randomly according to age and sex. Many artiodactyl species are clumped on the landscape according to age and sex, with adult males remaining separate from adult females and juveniles (Broughton 2002). Furthermore, some hunting techniques, such as mass capture techniques, may not discriminate according to age and sex when populatins are not segregated.

For the Fremont region, Ugan (2005) argues that increased adult mortality or increased local population levels of some game, in particular artiodactyls, should result in a wider range of age classes exploited by hunters. In his analysis of the faunal assemblage from Evans Mound and Median Village in Parowan Valley, he found a higher frequency of adult artiodactyls were present during climatic periods that would have favored higher local population abundances. He reevaluated his data using modified growth rates to redefine the age cutoff for adults depending on climatic conditions, arguing that higher forage quality would potentially result in faster growth rates. However, even without this data manipulation, Ugan's data follows the expectation that increased population levels would result in greater selectivity, represented by an increase in adult artiodactyls. His analysis is problematic, however, in that he aggregates artiodactyls together despite very different population structures between pronghorn, mountain sheep, and deer, the three artiodactyl species present at the Parowan Valley sites. Here, I review the age profile for each species separately to identify potential differences in the manner that their populations were exploited prehistorically.

I use two general methods to age animals from skeletal remains—tooth eruption and epiphyseal fusion—using published data from modern animals on the timing of these events (Hansen and Deming 1980; Heffelfinger 2010; Lewall and Cowan 1963; Robinette et al. 1957; Walker 1987). The primary exception was for neonatal (late fetal or newborn) specimens, which are common in the Five Finger Ridge assemblage. Based on comparative material, neonatal specimens from Five Finger Ridge appear to represent newborn fawns acquired during the first few weeks of life (see Chapter 2).

Tooth eruption provides the most dependable criterion for age but is dependent on the presence of relatively complete mandibular specimens (see Table 4.3). It should be noted that while both right and left mandibles were used for aging, there is only one case in which the two halves come from a single individual, both of which were recovered from the floor of Pithouse 3; all other mandibles from the same age class appear to be morphologically distinct in their patterns of tooth wear and bone morphology. As such, each specimen may be treated individually regardless of side.

4.3.1 Odocoileus

Mule deer occupy a great variety of habitats within the Upper Sonoran Life-zone with a relatively large home range (roughly 25-355 ha) (Anderson and Wallmo 1984; Durrant 1952; Hall 1981). Mule deer continue to gain weight up to eight years old for does and twelve years old for bucks (Anderson and Wallmo 1984). Sexual dimorphism appears beginning at eighteen months, with males attaining much greater weights (75-150 kg) than females (< 70 kg)(Anderson et al. 1974; Anderson and Wallmo 1984). Fat reserves are gradually built up during the summer, reaching a peak in fall shortly before breeding season (Anderson and Wallmo 1984). Seasonal movements from higher summer to lower winter elevations may occur among some populations, with the spring and fall migration between these locations taking approximately four weeks. Deer social groups consists of an adult doe and her yearling daughter and fawns (Nowak and Walker 1991). Males tend to be found either alone or in small groups of unrelated bucks (Anderson and Wallmo 1984), but larger groups of both sexes may aggregate during the winter (Nowak and Walker 1991).

The distribution of fused to unfused skeletal parts is used to identify the age profile of deer at Five Finger Ridge (Table 4.4). To simplify analysis, I combine the elements that fuse before 27 months (proximal radius and distal humerus and tibia), between 27 and 34 months (calcaneus, distal metapodials, and proximal femur), and after 34 months (proximal ulna, tibia, and humerus; distal radius, ulna, and femur). Using chi-square analysis, I found that there are significant differences in the frequency of fused to unfused specimens across these age categories ($\chi^2 = 22.04$, p = .001; Table 4.5). The high frequency of unfused specimens in the middle age class indicates that relatively young deer, especially those younger than 2.5 years, were generally acquired by the Five Finger Ridge hunters. The mandibular tooth eruption data likewise show that three of the six individuals (excluding neonatal specimens) were less than three years old at the time of capture (Table 4.6).

As previously noted, neonatal *Odocoileus* specimens are common in the Five Finger Ridge faunal assemblage. Female deer generally give birth to one to two fawns around mid-June to early July (Anderson and Wallmo 1984). For the first month, fawns stay hidden in dense vegetation (Nowak and Walker 1991). Thus, capture requires little to no pursuit, and hunters must simply know where these beds are located. Considering the relative ease of capturing young fawns, it is possible that these were targeted as a sessile resource and not hunted in the same manner (or at the same time) as adults.

Considering the smaller size of newborn deer, they are more likely to have been transported as complete individuals to Five Finger Ridge compared to more mature individuals. To test this, I first computed the Shannon evenness value for all neonatal artiodactyls since these values include post-cranial specimens that could not be identified to species but are most likely deer (see Chapter 2). The evenness value is relatively high (.798) and is not significantly different from the value for adult artiodactyls (.853; $t = 1.69$, $df = 121$, $p = .10$).

Since the evenness measure does not account for possible differences in the relative frequency of particular skeletal parts, I used a chi-square test to identify whether neonatal artiodactyls are represented by a different set of skeletal parts than adult artiodactyls. There is a significantly higher representation of neonatal head and teeth elements, and a lower frequency of lower front limb, lower hind limb, and foot elements (χ^2 = 239.81, p < .001; Table 4.7). The higher frequency of head elements matches the large number of neonatal mandibular specimens in Table 4.6 where fifteen of the twenty-one mandibular specimens represent newborn deer. As mentioned in Chapter 2 (Section 2.4.2.1), there is a high frequency of cutmarks on the head that represent skinning, and it may be that the different frequency of skeletal elements is a function of this activity. However, density-mediated destruction cannot be ruled out as the primary cause of this pattern, especially if high density portions are not distributed across the skeleton in the same manner as adults (Symmons 2005).

There are no significant changes through time in the relative frequency of neonatal to adult artiodactyls (χ^2 = 4.75, p = .09; Table 4.8), indicating that these individuals were an important component of the Five Finger Ridge economy through the occupation of the site.

4.3.2 Ovis

Mountain sheep are generally more isolated to specific habitats than deer, with a preference for rugged landscapes (Hall 1981). Although reaching sexual maturity by eighteen months, ewes reach full size by four years of age, while rams may continue to grow beyond eight years old (Hansen and Deming 1980; Shackleton 1985). Rams continue to travel with ewes until three years of age, when they then join bachelor groups (Turner and Hansen 1980).

In *Ovis*, most skeletal elements fuse at approximately two to three and one half years of age, with the order and timing of fusion events differing slightly from *Odocoileus* (Table

4.9). As with *Odocoileus*, I simplified comparisons by combining the elements that fuse before 27 months (proximal metapodials, radius, and phalanges; distal humerus; and scapula), between 27 and 29 months (distal metapodials and tibia), and after 29 months (proximal ulna, humerus, tibia, and femur; distal femur, radius, ulna; calcaneus; and innominate). I found that there are significant differences in the frequency of fused to unfused specimens across these age categories ($\chi^2 = 43.11$, $p = .001$; Table 4.10), with the >29 month old class having fewer fused specimens than expected. This matches the mandibular dentition data (Table 4.11), which shows that approximately 33.3% of the individuals are 2.5 years or younger (compared to 34.4% unfused specimens for the >29 month age group). The finer-grained resolution of mandibular tooth eruption and wear data also show that *Ovis* individuals were generally much older than *Odocoileus* at the time of capture. Only one deer individual (Specimen 10046-002) was older than five years old, while five (23.8%) of the mountain sheep exceeded this age.

There is an insufficient number of *Ovis* specimens from dated floor contexts to statistically evaluate changes in age profiles through time. Three mandibles recovered from Period 1 contexts represent individuals aged three and one-half years old, four years old, and greater than four years old. Period 2A had two mandibles belonging to a single individual aged approximately one year old, as well as a mandible of an individual older than five years. It is also worth noting that a single, nearly complete horn core was recovered from the floor of Pithouse 61 (Period 2A). The specimen measures approximately nine centimeters, but the distal fifth is missing. Given this length, it is estimated that the individual was approximately eight months old (Hansen and Deming 1980). Two mandibles from Period 2B are of individuals around four years old; both are from Pithouse 3 but appear to represent separate individuals based on morphology and tooth wear.

The relatively fine-grained aging provided by mandibular tooth eruption data allows some statements regarding hunting seasonality. Considering that lambing season ranges from mid-February to late May in Nevada (Turner and Hansen 1980), the presence of a six-month old indicates that some mountain sheep hunting must have occurred during late summer through late fall, possibly when populations were still occupying relatively high elevations. Populations at this time are relatively small and dispersed, consisting of rams, ewes, and juveniles (Simmons 1980). Two additional individuals are estimated to be approximately one year of age, thus would have been captured during lambing season. At this time, sheep populations are generally dispersed into large bands of adult ewes and juveniles and scattered groups of adult rams along steep and precipitous landforms (Simmons 1980).

Ovis mandibular specimens at Five Finger Ridge are frequently missing the lower second premolar, a condition known as mandibular hypodontia (Lyman 2010). Among modern sheep located in Nevada, for instance, 7.4% of rams and 34.3% of ewes have this trait (Allred et al. 1966; Bradley and Allred 1966). This characteristic was noted for four of the twelve Five Finger Ridge specimens with permanent premolar dentition (Table 4.12). These displayed no evidence of alveolar closing after the loss of the tooth, nor wear patterns on the mesial portion of the third premolar, indicating that the tooth was never present. Although other indicators of sex, such as size of skeletal parts, were not recorded for the Five Finger Ridge assemblage, the frequency of mandibular hypodontia suggests that a large portion of the assemblage consists of adult females.

4.3.3 Antilocapra

Pronghorn grow much more rapidly compared to other North American artiodactyls (O'Gara 2004), reaching full size by the time they are two years old. Female pronghorn become sexually mature at 16 months, and while yearling males are capable of breeding, they rarely are allowed to do so by older bucks (O'Gara 1978). Pronghorn generally give birth around mid-March to mid-June (O'Gara 1978). Pronghorn are relatively small artiodactyls compared to mountain sheep and mule deer, weighing between 36-70 kg with males averaging ten percent larger than females (Nowak and Walker 1991). Groups aggregate during winter in sagebrush communities, dispersing in spring to move into summer grassland ranges where they form herds of a fewer than a dozen does associated with an older buck’s territory, and slightly larger bachelor herds of yearling and two year old males (O'Gara 1978).

The three *Antilocapra* mandibular specimens are all from young individuals under a year and a half old (Table 4.13). One proximal metacarpal (total NISP =1) and one distal tibia (total NISP = 5) are unfused, and the epiphyseal line is still present in a second distal tibia specimen. It is unknown when these fuse in *Antilocapra*, but O’Gara (2004) reports that maximum growth of the hind feet is reached by eighteen months. Considering the more rapid growth of *Antilocapra*, these individuals are likely much younger than the estimates provided by epiphyseal fusion data for the remaining two medium-bodied artiodactyls. The lack of wear on the lower second premolar in Specimen 8169-001 indicates it is a very young individual, although the presence of completely erupted premolars and moderate bone develop indicates that it was not newborn when captured. This individual was likely acquired during late spring or summer.

4.4 Paleoenvironments and Changing Taxonomic Abundances

Density-mediated destruction has played a pivotal role in the representation of skeletal elements among different groups of taxa. As discussed in Chapter 3, the degree of attrition is highly variable between site contexts and between the two most abundant taxa present, the medium-bodied artiodactyls (*Ovis*, *Odocoileus*, *Antilocapra*, and unassigned artiodactyl) and *Sylvilagus*. This is especially apparent for the assemblages for the structure and activity area floors, the contexts which have the most secure dating. Although the underlying cause for this difference is not clear, the implication is that any evaluation of relative abundances between different kinds of taxa are impacted by the relative survivorship of each of the taxa involved. Specifically, measures such as the Artiodactyl Index (Broughton 1994) cannot be used to identify changes in the relative abundances of taxa through time. Yet temporal changes may still be evaluated by comparing similar taxa with one another if it is assumed that density-mediated destruction did not affect the relative abundances at the lower taxonomic or size class level, such as the relative frequency of the different leporids (*S. audubonii*, *S. nuttallii*, *Lepus* sp.) and artiodactyls (*Odocoileus*, *Ovis*) through time.

Local paleoenvironment records may be used to understand identified changes in faunal abundances. Pollen records from Sheep Shelter and Cave of 100 Hands, both located within two miles of Five Finger Ridge, provides local paleoclimatic data for the site (Newman 2000). Figure 4.6 displays the selected pollen profiles from the Cave of 100 Hands alongside some of the relative mammalian abundances discussed below. For the sake of simplifying the graphical representation, a number of indices are used that require explanation. To show the relative abundance of *Sylvilagus nuttallii*, the *S. nuttallii* index was computed by dividing the number of Nuttall's cottontail by the total number of *Sylvilagus* identified to species. The Leporid Index is computed by dividing the *Sylvilagus* NISP by the sum total of all leporids. Lastly, the *Ovis* Index is the total number of *Ovis* specimens divided by the sum total of all medium-bodied artiodactyls. The meaning of these indices will become clear in Sections 4.5.1-2

During the occupation of Five Finger Ridge, the pollen record from the Cave of 100 Hands indicate that there was a decrease in grasses and pine over *Artemisia* beginning shortly before AD 1100, indicating increased winter precipitation according to Newman (2000). Subsequently, grasses and pine become increasingly more dominant on the landscape, peaking by the end of Period 2A, signifying a shift towards greater summer precipitation. The ratio of sagebrush to grass pollen increases slightly during Periods 2B and 3, while the ratio of pine to sagebrush decreases more radically during this time. This may indicate cooler spring temperatures and increases in the amount of winter precipitation. Figure 4.7 illustrates the modern distribution of pinyon-juniper woodlands and sagebrush scrublands along an elevation profile. Changes in climate during the occupation of Five Finger Ridge appear to have resulted in changes in the species composition and elevation boundaries of these vegetation zones.

The data from Sheep Shelter roughly corresponds with the same pattern but with coarser resolution. There is a change in climate at AD 1150-1550, the period encompassing the majority of the occupation of Five Finger Ridge: juniper increases over pine, grass over sagebrush, and Cheno-Ams over sedges and cattails. Overall, this indicates a shift towards decreasing summer monsoonal precipitation, but winter precipitation likely persisted.

The Fremont Period corresponds well with climatic conditions that allowed for maize horticulture (e.g., Coltrain and Leavitt 2002; Madsen and Simms 1998; Talbot et al. 2000). The botanical data from Five Finger Ridge demonstrate shifting use of wild and cultivated plants through time (Talbot et al., 2000: 499-557). The relative abundance of *Zea* macrofossils fluctuates strongly through time in relation to other taxa. While relatively high in Period 1 (%NISP = 6.99, total NISP = 186), *Zea* spikes in frequency in Period 2A (%NISP = 25.89, total NISP = 409), and declines substantially in Period 2B (%NISP = 1.30, total NISP = 6473).

4.4.1 Leporids

The position of Five Finger Ridge at the edge of the current range of *S. audubonii* places the site in a particularly key location for evaluating paleoenvironments during the occupation of the site. In regions where both species of cottontails are present, *S. nuttallii* is limited to Upper Sonoran and Transition life zones at higher altitudes, while *S. audubonii* occupies the lower desert valleys, although it too requires some shrubby habitat and avoids open plains (Chapman 1975; Chapman and Willner 1978; Hall 1946; Hoffmeister 1986). Temporal fluctuations in the relative abundances of the two species may provide valuable information on the changing environmental conditions at the end of the Fremont period in the vicinity of the site.

As seen in Table 4.14, there is a change in the proportion of the two species, with *S. nuttallii* becoming more frequent through time. This is supported by a Cochran-Armitage test for trend ($\chi_t^2 = 3.98$, $p = .05$; $\chi_d^2 = .25$, $p = .62$); a Fisher's exact test for the Period 1 and 2B assemblages also shows a marginally significant difference in distribution ($p = .06$). Assuming that cottontail rabbits were captured locally, this data suggests that the low elevation threshold of *S. nuttallii*, and the high elevation threshold of *S. audubonii*, shifted downwards while the Five Finger Ridge was occupied. This change in turn likely reflects a shift toward cooler summer temperatures, one that impacted the distributions of preferred vegetation habitats. It is conceivable that cottontail rabbits were not captured locally, and instead the increased number of *S. nuttallii* reflects increased hunting of rabbits in upland areas. However, this would imply local *Sylvilagus* populations were significantly reduced by either overhunting or climate change, and that Fremont foragers responded by expanding hunting to only higher elevations. Considering the local pollen sequences and the high reproductive rates of leporids, the most parsimonious explanation is that there was a change in the kind of leporids present.

In a similar fashion, the relative abundances of *Lepus* sp. and *Sylvilagus* spp. may used to identify changes in the landscape. Jackrabbits and cottontail rabbits generally occur in distinct environments, with the former tending to prefer open landscapes with less dense vegetation. The relative abundance of the two leporids has frequently been used to evaluate environmental change, sometimes in relation to increased landscape manipulation by horticulturalists (Szuter 1991). Here I use chi-square analysis and Cochran-Armitage test for trend to identify significant differences. As seen in Table 4.15, the frequencies of *Lepus* decrease through time ($\chi_t^2 = 10.81$, $p < .001$; $\chi_d^2 = 1.77$, $p = .41$), providing additional support for a shift from a relatively open landscape to one with denser shrubs that supported *Sylvilagus*, specifically *S. nuttallii*, in the more recent occupations.

4.4.2 Artiodactyls

Changing relative abundances of the artiodactyl species present at Five Finger may be indicative of localized resource depression caused by hunting pressure or climate change, or differences in resource use and scheduling related to opportunity costs. As seen in Table 4.16, there are significant differences in the relative abundances of *Odocoileus* and *Ovis* between temporal periods ($\chi^2 = 16.69$, $p < .001$; Period 3 removed due to small sample size). There appears to be a shift from sheep to deer from Period 1 to Period 2A. Although I previously found no temporal changes in the relative abundance of neonatal to adult artiodactyls (Section 4.4.1), the relatively abundance of neonatal artiodactyl specimens increases in relation to *Ovis* specimens during Period 2A ($\chi^2 = 20.48$, $p < .001$).

The shifting abundances of artiodactyl species during Period 2A corresponds well with the local pollen profiles from Cave of 100 Hands and Sheep Shelter, suggesting that it is not resource depression that caused the marked decrease during Period 2A. Instead, the decreased abundance of sheep during this period may be the result of changing ranges that brought sheep father away from Five Finger Ridge, or alternatively, opportunity costs related to increased maize horticulture during this period.

Exactly how climate may have impacted prehistoric mountain sheep populations is not clear, but it may relate to altitudinal changes in range that led animals farther away from the Five Finger Ridge settlement. Mountain sheep typically inhabit open, rugged terrain (Hansen 1980; Krausman et al. 1999; Shackleton et al. 1999; Valdez and Krausman 1999). Desert bighorn will move into pine and juniper woodlands, but only when the density of the vegetation does not limit their visibility (Krausman, et al. 1999). The increase in pine over sagebrush pollen that corresponds with the decreased *Ovis* representation during Period 2A may indicate that favorable summer habitats for sheep shifted in altitude, requiring increased transport costs for Five Finger Ridge hunters.

The age mortality profile as a whole suggests that sheep hunting generally occurred when populations were at higher elevations. Actual elevation ranges are not described for desert bighorn (*O. canadensis nelsoni*) in Utah. Whiting et al. (2004) report that transplanted populations of Rocky Mountain bighorn (*O. c. canadensis*) on Mount Timpanogos and Rock Canyon in north-central Utah occupy a mean elevation of 1904 ± 292 m in the winter, move up in elevation during lambing season to 2054 ± 262 m. A separate population located further south on Mount Nebo occupy higher elevations during winter (2172 m) and lambing (2547 m) seasons than more northern populations (Shannon et al. 2008). Such elevations are present within two kilometers of Five Finger Ridge (Figure 4.7), but it is risky to use these data for prehistoric populations at a more southerly latitude, for a potentially different subspecies, and during a period of climatic change.

Alternatively, increased opportunity costs associated with maize cultivation may have limited sheep hunting. The climatic conditions during Period 2A were favorable for maize horticulture, and the correlation between climate and decreased *Ovis* abundances may not be causal. Instead, scheduling economic activities may have precluded mountain sheep hunting.

In the next chapter, I use stable isotopes to identify whether local mountain sheep populations were significantly reduced, resulting in hunters traveling to new herds farther away, or whether the same populations were hunted but at a lower frequency.

Unfortunately, data on the two remaining artiodactyl species, bison and pronghorn, are too sparse to identify any clear changes in resource use through time. Pronghorn, while always rare in the assemblage, increases in relative frequency during Period 2B. This may have been the result of Five Finger Ridge hunters using more distant large game populations.

4.5 Discussion

The data presented above on relative skeletal abundances, demographics, and relative temporal abundances may be used collectively to understand the nature of animal exploitation at Five Finger Ridge and its relationship to climate, local prey population abundances, and the overall importance of different mammalian resources to the Fremont diet at Five Finger Ridge.

The location of Five Finger Ridge at the modern altitudinal boundary between *Sylvilagus audubonii* and *S. nuttallii* has provided a unique opportunity to compare the relative frequency of the two species through time with corresponding changes in a local pollen profile. Such a change in cottontail species has not previously been documented in the eastern Great Basin, and provides essential data for understanding the role of paleoenvironments in determining the historic distribution of *Sylvilagus*. As such, it may be added to a growing database of mammalian responses to climate change in the region (Grayson 2006; Grayson and Fisher 2009).

The patterns seen in the skeletal part representation, age demographics, and relative abundances of each artiodactyl species in the Five Finger Ridge assemblage appear to reflect changing resource availability, although this is not necessarily the result of hunting pressure. The artiodactyl assemblage showed a significant decrease in evenness values driven largely by decreased frequencies of lower utility body parts at Five Finger Ridge. This suggests that the decisions made regarding the transportation of different body parts changed during the occupation of the site, possibly reflecting greater distances traveled to acquire large game that resulted from decreased artiodactyl population levels. The slight increase in pronghorn in the Period 2B assemblage provides additional support that hunters were traveling farther abroad to acquire large game. However, this data alone cannot be used to demonstrate whether increased travel distances were the result of human predation pressure or climate change.

If Broughton (2002; Munro 2004; Ugan 2005) is correct in supposing that hunters should target older artiodactyl individuals due to their increased size, it does not appear that *Ovis* populations were being significantly impacted by local Fremont hunters. The mountain sheep age profile ranged from six months to greater than five years old, and the five individuals aged older than five years likely include fully-grown adults judging from the high levels of wear on some individuals. Combined with the corresponding changes in climate, these data suggest that the decreased abundance of *Ovis* during Period 2A was not the result of overhunting. In contrast, the age mortality data suggest that *Odocoileus* populations were being depressed, resulting in lower mean age of capture than that observed in modern deer populations and in the Five Finger Ridge *Ovis* assemblage. Unfortunately, the sample size is too low from dated contexts to determine whether there is any change through time for both of these species.

The abundance of neonatal *Odocoileus* specimens indicates that hunting of at least this class of animals occurred during mid-summer, which may have been an opportunistic time between planting and harvesting of horticultural crops (Barlow 2002). The increased focus on maize cultivation during Period 2A may have resulted in greater degree of tethering to the residential base, forcing hunters to focus efforts towards more local deer populations. The decrease in *Ovis* specimens during this period may not be due to a shift in herd locations as a response to climate, but instead a result of increased opportunity costs associated with maize farming.

4.6 Conclusion

Distinct changes in the relative frequency of taxa correspond largely with paleoenvironmental data recovered from pollen cores in the vicinity of Five Finger Ridge. Altitudinal shifts in favorable habitats appear to have influenced the local availability of the leporid species and mountain sheep. Simultaneously, shifts in summer precipitation and temperature impacted horticultural activities. When conditions for maize farming were optimal, it appears that the occupants of Five Finger Ridge placed greater emphasis on deer populations, potentially resulting in localized resource depression. Unfortunately, a more thorough analysis of changing diet breadth that may have corresponded with decreased availability of large game in the vicinity of the site cannot be identified due to differences in taphonomy between small and large mammals at the site.

Taken alone, the data presented here suggests that mountain sheep became especially rare during Period 2A, and their value as a signaling species may have subsequently increased. To substantiate this claim, independent data is necessary to demonstrate that the decreased abundances of mountain sheep in the Five Finger Ridge assemblage is truly a reflection of decreased population levels in the vicinity of the site. In the next chapter, I will use stable isotopes to identify potential changes in the geographic origin of sheep and deer to make such a claim.

Tables

Table 4.1. Frequency (NISP) and chi-square adjusted residuals for anatomical units among Odocoileus and *Ovis*. *: p < .001; **: p < .01; ***: p < .05

	Odocoileus	***Ovis***
Head	102	98
Adj. Res.	+1.67	-1.67
Teeth	81	90
Adj. Res.	+0.51	-0.51
Axial	33	45
Adj. Res.	-0.59	+0.59
Upper Front	86	63
Adj. Res.**	+3.15	-3.15
Lower Front	113	214
Adj. Res.*	-4.55	+4.55
Upper Hind	18	21
Adj. Res.	+0.08	-0.08
Lower Hind	136	123
Adj. Res.***	+2.49	-2.49
Feet	76	117
Adj. Res.	-1.85	+1.85

Table 4.2. Frequency (NISP) and chi-square adjusted residuals for medium-bodied artiodactyl anatomical units among temporal periods. *: p < .001; **: p < .01; ***: p < .05

	Period 1	**Period 2A**	**Period 2B**
Head	34	20	23
Adj. Res.	+1.20	+0.60	-1.70
Teeth	12	5	5
Adj. Res.	+1.60	0.00	-1.60
Axial	91	55	59
Adj. Res.	+2.20***	+1.30	-3.40*
Upper Front	13	13	19
Adj. Res.	-1.30	+0.90	+0.50
Lower Front	43	21	55
Adj. Res.	-0.40	-1.60	+1.90
Upper Hind	14	8	11
Adj. Res.	+0.50	+0.10	-0.60
Lower Hind	47	36	97
Adj. Res.	-3.80*	-1.30	+4.80*
Feet	26	15	16
Adj. Res.	+1.20	+0.50	-1.70

Table 4.3. Criteria used for aging artiodactyl mandibular specimens (from Heffelfinger 2010)

Taxon	Age	Notes
Odocoileus	1.5 years	Deciduous P_4 well worn; M_{1-2} erupted; M_3 not fully erupted
	2.5 years	Permanent P_4 erupted; little wear on last cusp of M_3
	3-5 years	M_3 last cusp with exposed dentine (U-shaped); dentine wider than enamel on M_1, but lingual crest still prominent
	6-8 years	M_1 worn smooth with no lingual crests
	8+ years	M_1 worn to gumline; teeth missing
Antilocapra	1.5 years	Deciduous P_4 is well worn; M_3 partially erupted, except for last cusp
	2.5 years	Permanent P_{2-4} erupting; M_3 fully erupted; 12 infundibula present on PM_{2-4}, M_{1-3}
	3.5 years	Permanent P_{2-4} fully erupted and stained; 12 infundibula present on PM_{2-4}, M_{1-3}, although 1 may be missing on M_1
	4.5 years	9-10 infundibula present; absent on M_1
	5.5 years	7-8 infundibula present; absent on M_{1-2}
	6.5 years	5-6 infundibula present; absent on PM_4, M_{1-2}
	7+ years	<4 infundibula present
	9+ years	No infundibula present
Ovis	6 mo.	Deciduous PM_{2-4} present; M_1 erupting
	1 year	Deciduous PM_{2-4}, M_1 erupted; M_2 erupting
	2.5 years	Permanent P_{2-3} erupting; M_3 erupting
	3.5 years	PM_{2-4}, M_{1-3} erupted; little wear
	4+ years	Increased level of wear

Table 4.4. Age designations for *Odocoileus hemionus* based on epiphysial fusion events with frequency (NISP) of fused to unfused skeletal parts. Age for fusion events taken from Lewall and Cowan (1963).

Element	Fusion Age (months)	Fused	Unfused	%Fused
Radius, Prox	14	10	1	91
Humerus, Dist	14-17	32	0	100
Tibia, Dist	14-15	27	4	87
Calcaneus	27-35	18	4	82
Metacarpal	29-29	5	6	45
Femur, Prox	29-34	0	1	0
Metatarsal, Dist	29-35	15	13	54
Ulna, Prox	34-35	4	1	80
Radius, Dist	34-60	1	4	20
Tibia, Prox	34-60	1	0	100
Humerus, Prox	35-60	0	0	--
Ulna, Dist	35-60	1	0	100
Femur, Dist	35-52	0	0	--

Table 4.5. Frequency (NISP) of fused to unfused *Odocoileus* specimens across age classes.

	Fused	Unfused	Adj. Res. (Fused)
< 27 months*	69	5	+4.69
27-34 months*	38	24	-3.86
> 34 months	7	5	-1.61

Table 4.6. Age designations for *Odocoileus hemionus* based on tooth eruption and wear of mandibular teeth.

Specimen	Context	Side	Age	Notes	Period
10311-001	Activity Area 27 Floor	R	Neonatal	M_1 nearly erupted, M_2 in formation, fragments of $DPM_?$	
9723-059	Activity Area 13 Fill	L	Neonatal	DPM_4 and others	
8077-001	Activity Area 9 Fill	R	Neonatal	DPM_{2-4}	
8178-001	Structure 28 Fill	L	Neonatal	DPM_{2-4}	
8207-001	Structure 29 Floor	L	Neonatal	DPM_{2-4}	1
9446-085	Structure 30 Floor	L	Neonatal	DPM_{2-4}	1
9616-023	Structure 35 Fill	R	Neonatal	DPM_{2-3}	
9800-040	Structure 39 Fill	R	Neonatal	DPM_{3-4}, mesial M_1 present	
8387-041a,b	Structure 43 Fill	R, L	Neonatal	DPM_{2-4}; M_1 in develoDPMent	
8403-014	Structure 43 Fill	R	Neonatal	DPM_{3-4}, M_1 in develoDPMent	
8414-006	Structure 43 Vent Fill	R	Neonatal	DPM_4;M_1 in formation	
10149-007	Structure 48 Vent Fill	L	Neonatal	DPM_{2-4}, M_1 in formation	
9204-162	Structure 56 Fill	R	Neonatal	DPM_{2-4}, M_1 in formation	
10231-093	Structure 62 Subfloor	L	Neonatal	DPM_{2-4}, M_1 in formation	2B
9783-002	Activity Area 24 Fill	R	<1.5 years	DPM_{2-4}; minor wear	
9889-001	Structure 57 Fill	L	<1.5 years	DPM_{2-4}, M_{1-2} erupted; M_3 partially erupted; developing PM_{3-4}	
8390-001	Structure 4 Fill	R	2.5 years	PM_{2-3}, M_3; minor wear	
8644-001a, 8687-001b; 8685-002, 8688-001	Structure 75 Floor	R, L	3.5 years	PM_{2-4}, M_{1-3}; moderate wear	2B
9546-002	Structure 32 Fill	R	3-5 years	PM_{3-4}, M_{1-3};moderate wear	
10046-002	Pithouse 62 Floor	L	~ 8 years	PM_{3-4}, M_1;heavy wear, close to gumline on M_1	2B

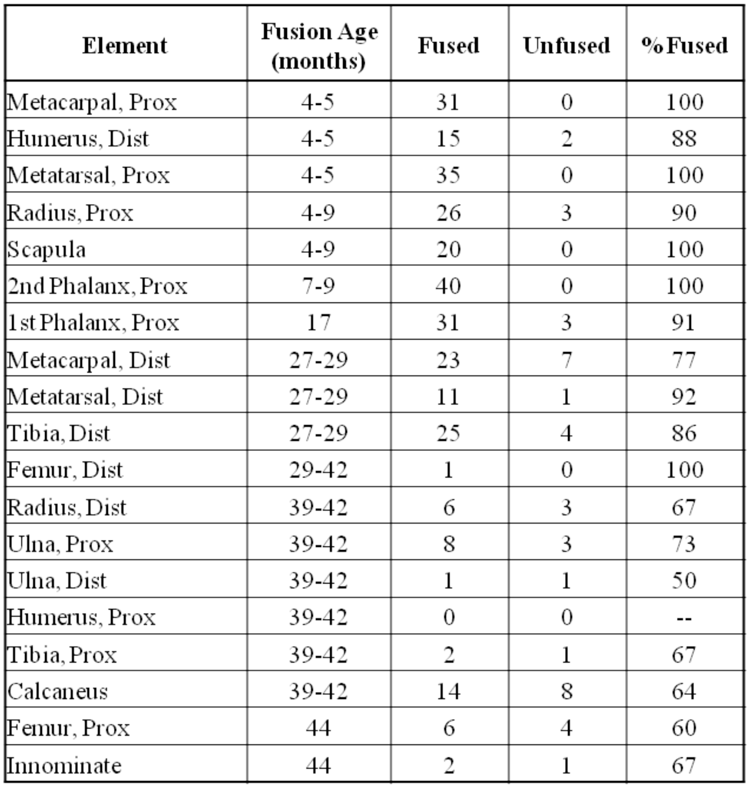
Table 4.7. Frequency (NISP) of anatomical units among neonatal and adult artiodactyls. *: $p < .001$; **: $p < .01$; ***: $p < .05$

Element	Neonatal	Adult	Adj. Res. (Neonatal)
Head*	111	296	+11.87
Teeth*	67	234	+7.09
Axial	107	1016	-1.02
Upper Front	30	313	-1.00
Lower Front**	33	484	-3.15
Upper Hind	23	180	+0.49
Lower Hind*	19	762	-8.06
Feet***	25	325	-2.04

Table 4.8. Frequency (NISP) of neonatal and adult artiodactyla specimens through time. *: $p < .001$; **: $p < .01$; ***: $p < .05$

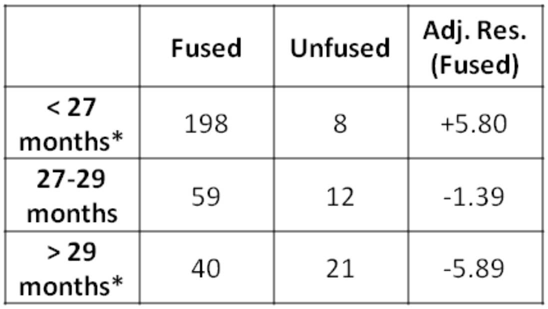
	Neonatal	Adult
Period 1	36	216
Period 2A	41	182
Period 2B	44	301
Period 3	1	16

Table 4.9. Age designations for *Ovis* based on epiphysial fusion events with frequency (NISP) of fused to unfused skeletal parts. Age for fusion events taken from Walker (1987).



Element	Fusion Age (months)	Fused	Unfused	% Fused
Metacarpal, Prox	4-5	31	0	100
Humerus, Dist	4-5	15	2	88
Metatarsal, Prox	4-5	35	0	100
Radius, Prox	4-9	26	3	90
Scapula	4-9	20	0	100
2nd Phalanx, Prox	7-9	40	0	100
1st Phalanx, Prox	17	31	3	91
Metacarpal, Dist	27-29	23	7	77
Metatarsal, Dist	27-29	11	1	92
Tibia, Dist	27-29	25	4	86
Femur, Dist	29-42	1	0	100
Radius, Dist	39-42	6	3	67
Ulna, Prox	39-42	8	3	73
Ulna, Dist	39-42	1	1	50
Humerus, Prox	39-42	0	0	--
Tibia, Prox	39-42	2	1	67
Calcaneus	39-42	14	8	64
Femur, Prox	44	6	4	60
Innominate	44	2	1	67

Table 4.10. Frequency (NISP) of fused to unfused *Ovis* specimens across age classes. *: p < .001



	Fused	Unfused	Adj. Res. (Fused)
< 27 months*	198	8	+5.80
27-29 months	59	12	-1.39
> 29 months*	40	21	-5.89

Table 4.11. Age designations for *Ovis canadensis* based on tooth eruption and wear of mandibular teeth.

Specimen	Context	Side	Age	Notes	Period
9062-001	Structure 22 Fill	L	6 months	$DPM_{2\text{-}4}$ with no wear, M_1 erupting	
8113-002	Activity Area 9, Fill	R	1 year	DPM_4, M_1 erupted; M_2 erupting	
8304-001a,b	Structure 5 Floor	R, L	1 year	$i_{1\text{-}2}$, $DPM_{2\text{-}4}$, $M_{1\text{-}2}$; M_2 erupting	2A
9289-001	Structure 21 Fill	R	1.5 years	DPM_2, DPM_4, M_1 with moderate wear; root absorption present	
9289-002	Structure 21 Fill	R	1.5 years	$DPM_{2\text{-}4}$, M_1 with moderate wear	
9485-005	Structure 57 Fill	R	1.5 years	$DPM_{2\text{-}4}$, M_1, and fragmented M_2 present	
9126-001	Structure 14 Fill	R	2.5 years	$M_{1\text{-}2}$ with no wear; M_3 unerupted but visible	
10209-025	Structure 45 Fill	R	3 years	$PM_{2\text{-}4}$, $M_{1\text{-}3}$; M_3 not completely erupted	
8251-001	Activity Area 8 Fill	L	3 years	DPM_2, DPM_4, $M_{1\text{-}2}$ with space for M_3; $PM_{3\text{-}4}$ erupting	
8312-005	Structure 17 Fill	L	3.5 years	$PM_{3\text{-}4}$, $M_{1\text{-}3}$; possibly slight wear on M_3	
10232-001	Structure 61 Fill	L	3.5 years	$PM_{2\text{-}3}$ with slight wear	
8265-186	Structure 26 Fill	R	3.5 years	$PM_{2\text{-}3}$, $M_{1\text{-}3}$	
8208-001	Structure 29 Floor	R	3.5 years	$PM_{2\text{-}4}$, M_3	1
8102-001a-b	Structure 3 Floor	L	4 years	$PM_{3\text{-}4}$, $M_{1\text{-}3}$; M_3 with little wear	2B
8099-001	Structure 3 Floor	R	4 years	$PM_{2\text{-}4}$, $M_{1\text{-}3}$; wear on $P_{3\text{-}4}$ only	2B
8225-001	Structure 28 Floor	L	4 years	$PM_{3\text{-}4}$, $M_{1\text{-}3}$, with little wear on M_3	1
8001-001	West Finger, Surface	R	5+ years	$PM_{3\text{-}4}$, M_1; space for M_2; moderate wear	
8113-003	Activity Area 9, Fill	L	5+ years	PM3-4, M1-3; moderate wear	
8220-001	Structure 28 Floor	L	5+ years	$M_{2\text{-}3}$ and portion of M_1; moderate wear	1
8179-001a, 8907-001b	Structure 28, Structure 29 Fill	R	5+ years	$PM_{2\text{-}4}$, $M_{1\text{-}2}$, strong wear	
10249-023	Activity Area 24	R	5+ years	$PM_{2\text{-}4}$, $M_{1\text{-}3}$; strong wear	2A

Table 4.12. Presence of mandibular hypodontia among adult *Ovis canadensis*

Specimen	PM_2 Absent	PM_2 Present
8251-001		X
10209-025		X
10232-001		X
8265-186		X
8208-001		X
8102-001a-b	X	
8099-001		X
8225-001	X	
8001-001	X	
8113-003	X	
8179-001a, 8907-001b		X
10249-023		X
Total	**4**	**8**

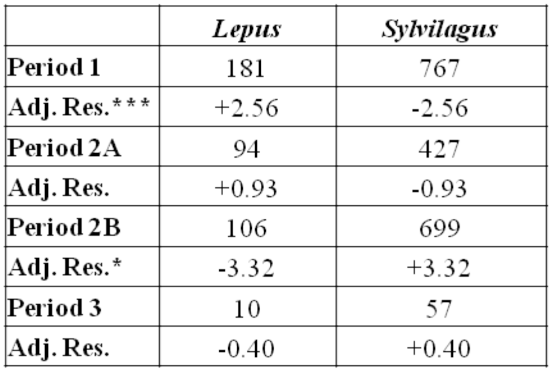
Table 4.13. Age designations for *Antilocapra americana* based on tooth eruption and wear of mandibular teeth.

Specimen	Context	Side	Age	Notes	Period
8169-001	Structure 28 Floor	R	< 6 month	DPM_2 with no wear	1
9506-006	Structure 23	R	1.5 year	$DPM_{2\text{-}4}$	
10041-002	Structure 62	L	0.5-1.5 year	$DPM_{2\text{-}4}$ with heavy wear; M_1 erupted, M_2 50% erupted	2B

Table 4.14. Frequency (NISP) of *S. nutallii* and *S. audubonii* across temporal periods.

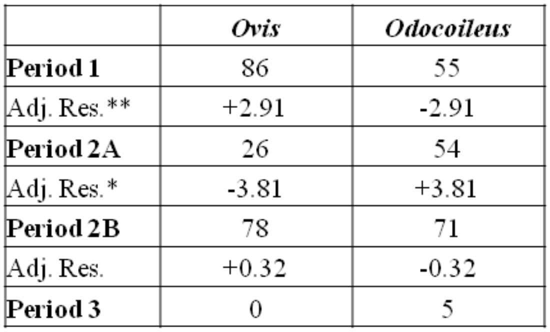
	S. audubonii	*S. nuttallii*
Period 1	12	7
Period 2A	6	9
Period 2B	7	15

Table 4.15. Frequency (NISP) of *Sylvilagus* and *Lepus* across temporal periods. *: p < .001; **: p < .01; ***: p < .05



	Lepus	*Sylvilagus*
Period 1	181	767
Adj. Res.***	+2.56	-2.56
Period 2A	94	427
Adj. Res.	+0.93	-0.93
Period 2B	106	699
Adj. Res.*	-3.32	+3.32
Period 3	10	57
Adj. Res.	-0.40	+0.40

Table 4.16. Frequency (NISP) of *Ovis* and *Odocoileus* across temporal periods. *: p < .001; **: p < .01



	Ovis	*Odocoileus*
Period 1	86	55
Adj. Res.**	+2.91	-2.91
Period 2A	26	54
Adj. Res.*	-3.81	+3.81
Period 2B	78	71
Adj. Res.	+0.32	-0.32
Period 3	0	5

Figures

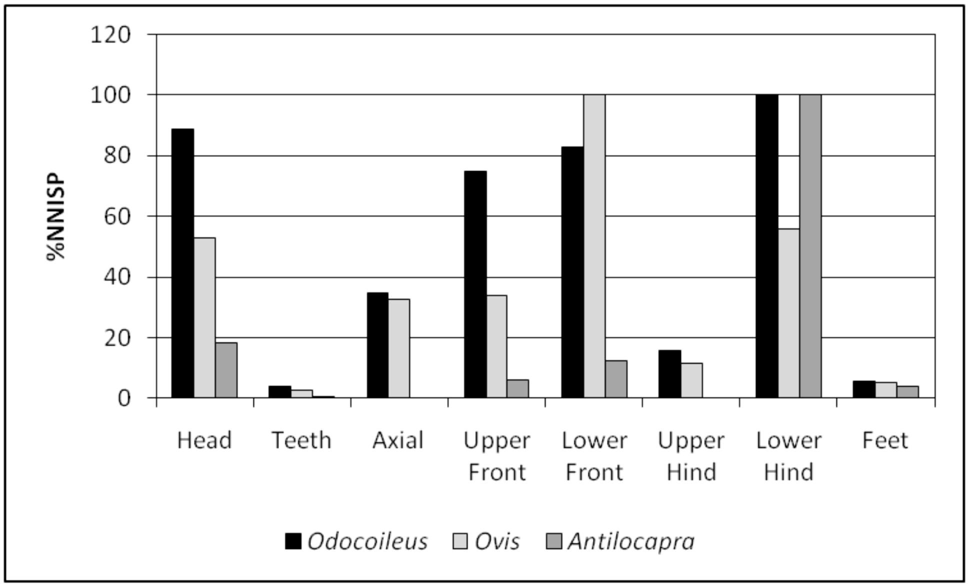


Figure 4.1. Relative Skeletal Abundances for the three medium-bodied artiodactyl species.

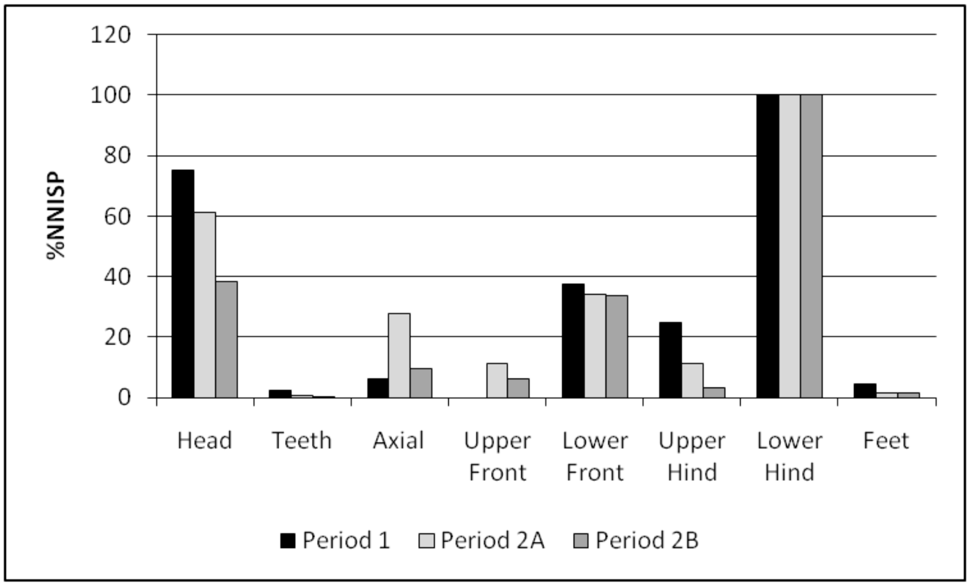


Figure 4.2. Relative Skeletal Abundances per temporal unit for *Odocoileus*.

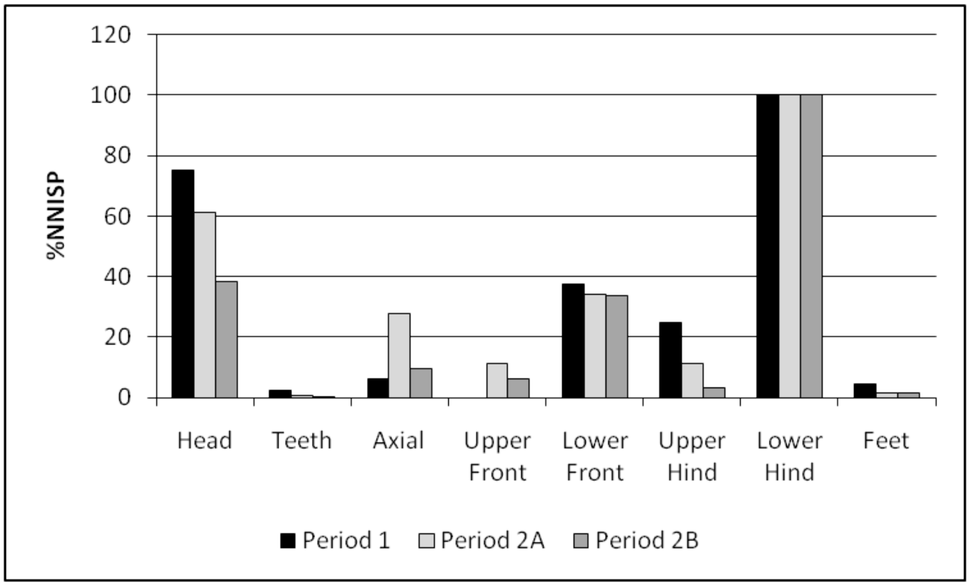


Figure 4.3. Relative Skeletal Abundances per temporal unit for *Ovis*.

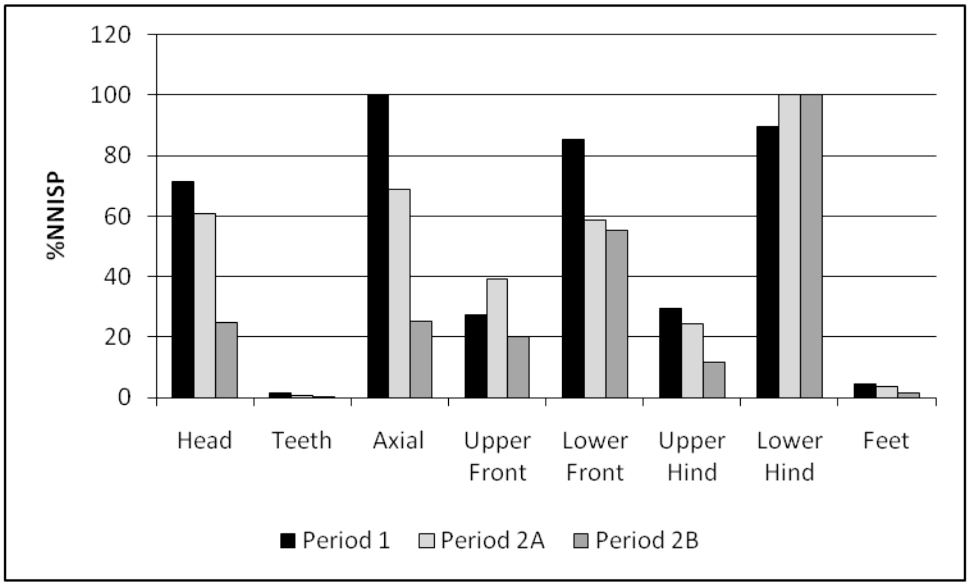


Figure 4.4. Relative Skeletal Abundances per temporal unit for combined medium-bodied artiodactyls.

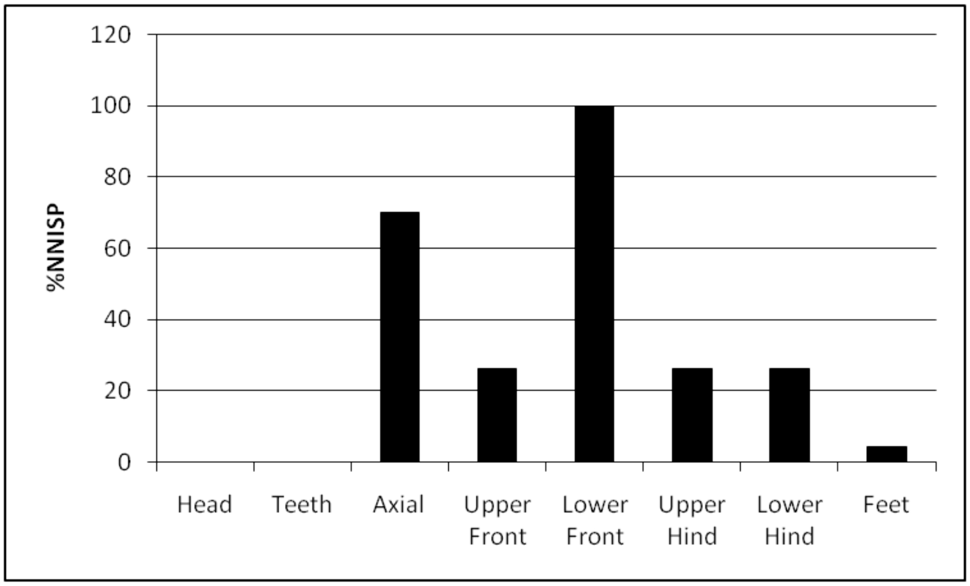


Figure 4.5. Relative Skeletal Abundances for *Bison*.

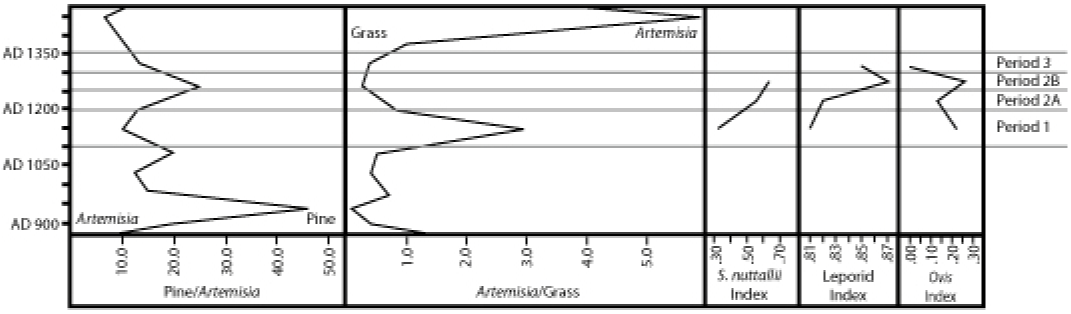
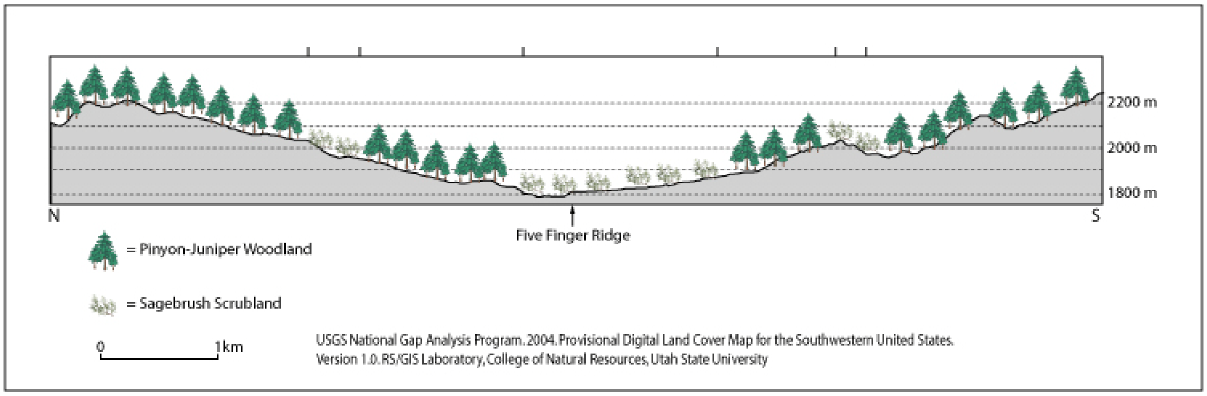


Figure 4.6. Paleoenvironmental profiles for selected species. Pollen data from Newman (2000). *S. nuttallii* Index is the ratio of mountain cottontail over all *Sylvilagus* spp. Leporid Index is the ratio of *Sylvilagus* spp. over all leporids. *Ovis* Index is the ratio of mountain sheep over all artiodactyls.



USGS National Gap Analysis Program. 2004. Provisional Digital Land Cover Map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University

Figure 4.7. Modern distribution of pinyon-juniper woodlands and sagebrush scrubland along a north-south transect through Five Finger Ridge.

Chapter 5

STABLE ISOTOPES AND LOCAL RESOURCE ABUNDANCES

5.1 Introduction

Identifying changes in landscape use is important for understanding a variety of human behaviors, including human-environment interactions. Over the past few decades, a variety of studies have used optimal foraging theory to detect changes in resource use across time that occur as a result of climatic change, human predation, and other potential factors (Bird and O'Connell 2006; Lupo 2007). Since paleontological faunal records are lacking in many regions, local prey abundances are frequently determined using archaeological assemblages by assuming that hunters base their foraging decisions on the prey-choice model. If foragers hunt optimally based on local resource abundances and caloric net return rates, the relative frequencies of high-ranked species in the archaeological record will reflect their local population levels since hunters should always dispatch these prey on-encounter (Broughton and Grayson 1993). Resource depression of high-ranked resources will result in higher frequencies of lower-ranked resources and possibly increased diet breadth.

Unfortunately, this approach suffers from two serious problems. First, it has become increasingly clear that hunters may not always base their decisions on optimality, but on factors related to costly-signaling (Bird 1999; Hawkes and Bliege Bird 2002; Hildebrandt and McGuire 2002; Smith et al. 2003). While the prey-choice model assumes random encounters with game, some hunters may target prey animals that are valued for their signal quality and not energetic returns. If some animals are valued for their rarity, this may result in an equifinality problem; species that were locally rare may be common in the archaeological record due to signaling hunting, and thus the archaeological record itself cannot be used as an indicator of local resource abundances.

Second, the most basic unit used in resource depression and diet breadth studies is the number of identified skeletal remains per taxa (NISP). This assumes that NISP values are an accurate reflection of local animal abundances, but this may be violated if the survivorship of skeletal parts is not constant across time and space. In Chapter 3, I demonstrated differences in attrition between artiodactyls and cottontail rabbits that explains a significant portion of the variation seen in the Artiodactyl Index.

Selective transport of skeletal parts may also impact relative taxonomic abundances, and others have shown the importance of incorporating transportation inferences in resource depression studies (Broughton 1994; Nagaoka 2005). However, such arguments assume that hunters optimally select different parts of an animal according to energetic value, and this again may be violated by hunters motivated by costly signaling. Even if hunters were selecting body portions for transport based on net energy returns, the decisions are based on a wide range of variables that cannot be identified archaeologically, such as the number of individuals in a hunting party, the condition of the animal once located, and other factors (Bartram 1993; Lupo 2006).

Both of these issues can be resolved using stable isotope data to demonstrate changes in landscape use across time within a site. If a region has sufficient levels of geological heterogeneity, it is possible to identify where resources were exploited both in relative terms (e.g., the number of patches exploited at a given time) or in absolute terms (e.g., specific patches exploited based on a matching geological signature) by using isotopes or trace elements that link an animal to specific geological formations.

Five Finger Ridge provides an excellent case study for testing the applicability of stable isotopes for making transportation inferences. The local geography of north-south trending mountain ranges and valleys provides a highly variable geologic setting, and it is expected that hunters traveling abroad in search of large game would transport animals from a variety of locations back to residential sites. Furthermore, I uncovered a number of patterns in Chapter 4 that are suggestive of decreased local prey abundances and increased transportation based on relative taxonomic and anatomical part abundances, and these inferences would be strengthened significantly with isotopic analysis.

First, the decrease in mountain sheep during Period 2A appears to be correlated with increased summer precipitation, but exactly how this change impacted hunters at Five Finger Ridge is not clear. On one hand, there may be a direct causal relationship with climate, with local sheep populations being significantly reduced or relocating to more favorable areas. However, there is also the possibility that people simply were not hunting sheep during this period due to economic conflicts with maize horticulture, which increases at this time as a function of climate change. This may be tested simply using heavy stable isotopes to determine whether hunters were acquiring fewer sheep from the same locations or new populations elsewhere.

Second, I found that the relative abundances of artiodactyl anatomical parts appear to change from the earliest to the latest occupation of the site. This does not necessarily mean that artiodactyls were captured at a greater distance from the site, but simply that transport conditions changed through time. A wide range of variables aside from distance alone determine what body parts will be transported, such as the number of individuals in a hunting party. The changing anatomical part profiles may instead be reflecting a shift from small group hunting parties to individual hunters, for example. If people were traveling further to capture artiodactyls, this may be reflected in changing heavy isotope values through time.

Thus, both of these findings at Five Finger Ridge may be greatly substantiated with the use of isotopic data. This data may also be informative regarding artiodactyl responses to environmental changes occurring at the end of the Fremont Period.

5.1.1 Optimal Foraging, Costly Signaling, and Transportation

Since archaeologists cannot witness actual prey-choice decisions, the faunal record is used to identify temporal fluctuations in resource use to demonstrate changes in diet breadth as high ranked resources become more or less abundant. Unfortunately, archaeological applications frequently use circular logic: local abundances determine the rate at which higher ranked game are hunted, which results in the archaeological record, and in turn this is used to identify local abundances. Independent data are necessary to escape this problem. Paleoenvironmental data may be used to demonstrate that changing abundances of prey in the archaeological record corresponds with local environmental conditions (e.g., Byers and Broughton 2004; Grayson and Cannon 1999; Ugan 2005), but these data generally cannot be used to demonstrate resource depression resulting for human predation. Alternatively, some archaeologists have successfully turned to transportation inferences, with the expectation that locally depressed prey populations will result in greater travel distances (e.g., Broughton 1994; Nagaoka 2005).

Understanding the decision-making processes involved in the transportation of resources has been a major component of a variety of optimal foraging models used in archaeology (e.g., Beck et al. 2002; Bettinger et al. 1997; Bird et al. 2002; Jones and Madsen 1989; Madsen et al. 2000; Zeanah 2000). The underlying principle of these models is that individuals will maximize their net returns by reducing transportation costs. This may be accomplished by reducing weight by removing unwanted material (e.g., cortex from rocks, low energy-yielding parts from animals), by shifting residential bases according to resource locations, and other means.

In zooarchaeology, a common technique is to identify the portions of an animal present at the site with the assumption that parts with high economic value are more likely to be retained. Although he does not explicitly posit his model in terms of optimal foraging, Binford (1978) developed a series of utility indices using ethnoarchaeological observations. In this regard, he implicitly uses optimal foraging theory by arguing that the body parts selected will depend on the marginal net returns of each portion and the costs of transporting these to a second location (Grayson 1988). The use of utility index values and similar measures provided by others (Madrigal and Capaldo 1999; Metcalfe and Jones 1988; Morin 2007) have become routine in zooarchaeological analyses, and has proven useful for resource depression studies (Chapter 4).

Unfortunately, there are a number of problems with using utility indices for inferring transportation. Field processing methods may vary depending on a number of other variables aside from distance and weight, such as the number of individuals available, the kind of animal, and various cultural practices for treating raw meat (Bartram 1993; Lupo 2006; O'Connell et al. 1990). For instance, Bartram (1993) found that the relationship between element transport, the number of transporters, and the distance from residences to be statically insignificant among the Kua, although others have found these relationships to be significant (e.g., O’Connell et al., 1990).

Recent ethnographic work has also demonstrated that hunters do not always forage optimally, and instead target prey that have higher risks and lower reliability, especially large game (reviewed by Bird 1999; see also Hawkes 1990, 1992, 1996; Hawkes and Bliege Bird 2002). If some animals are targeted for reasons outside of energy-based optimal foraging, it may follow that hunters also make transport decisions based on signaling motivations as well. Hunters traveling father abroad to capture prey with high signaling value may be bringing back the entire animal, especially if widespread sharing is critical for forming an audience for the signal. As such, the relative abundance of some taxa and their skeletal parts may remain unchanged in the archaeological record despite decreased local prey populations and increased travel distances.

Bone attrition has also proved to be a conflating issue when making transportation inferences based on skeletal part representation (Grayson 1989; Lyman 1985; Marean and Frey 1997). As discussed in Chapter 3, the relationship between carcass transportation, modified general utility indexes, and bone density has been explored at depth, revealing inconsistencies in the link between behavior and archaeological correlates. If density-mediated destruction is significant, as it is at Five Finger Ridge, relative skeletal abundances may not be an accurate reflection of human behavior but instead of taphonomic processes. This may be circumvented by using anatomical units, although this may limit the kinds of analyses conducted by significantly reducing the number of categories used (Stiner 2002; Chapter 4).

5.1.2 Strontium Isotopes and Local Prey Abundances

To resolve this problem, I suggest that the degree of transportation and resource depression may be reliably detected using isotopic signatures by identifying the number of different prey populations targeted at any given time. Depressed prey populations are expected to force hunters to incorporate more distant populations in addition to those previously exploited. Populations may be identified using stable isotopes that track an individual's movement along the landscape.

Although strontium has only rarely been used for sourcing hunting locales (e.g., Grimstead and Reynolds 2008), the same general technique is commonly used to establish prehistoric human migration (see Benson et al. 2006; Bentley 2006; and Hoppe 2004 for other examples). Strontium ratio values ($^{87/86}$Sr) in animals are determined by the amount of strontium in their diet, which in turn is determined by the biologically-available $^{87/86}$Sr in water and soil via plants and animals. As long as the geologic region provides heterogeneous isotopic compositions, strontium isotope signatures may be used to identify different populations of animals on the landscape. There is a wide range of geologic features in the region surrounding Five Finger Ridge, demonstrating sufficient heterogeneity (Figure 5.1).

The relatively discrete home ranges and seasonal migration of each species suggest that strontium analysis will be effective at determining specific populations (Chapter 4).

Intra-tooth sampling has been used with great success to identify seasonal and migratory patterns among herbivores (e.g., Balasse 2003; Balasse et al. 2002; Bentley et al. 2004; Britton et al. 2009; Hoppe et al. 1999; Zazzo et al. 2006; Zazzo et al. 2005). Dental tissues form sequentially and undergo little remodeling once fully developed (Hillson 2005), and serial sampling of teeth tracks an individual's movements during the time of tooth development. Comparison of these life histories allows for the identification of specific populations, as individuals within a single population should have similar life histories that crosscut the same local geology.

Most artiodactyl species have recurring annual migration routes between seasonal home ranges (e.g., Anderson and Walmo 1984; Valdez 1999). Female mountain sheep have home ranges averaging 16.9 ± 3.4 km^2, while those of rams increase with age to areas as great as 37 km^2 (Shackleton 1985). Depending on the population, sheep utilize two (winter and summer) to as many as five home ranges (Shackleton 1985). The maximum distance between the winter and summer ranges is 48 km.

Mule deer have comparatively small home ranges of 0.25 to 3.5 km^2 (Anderson and Wallmo 1984; Durrant 1952; Hall 1981). There are seasonal shifts in home ranges, with migrations to lower elevations for the winter, where large groups of both sexes aggregate (Nowak and Walker 1991). Migrations between lower and higher elevations takes approximately four weeks, and the mean linear distance between the winter and summer ranges is 29.8 km (Anderson and Wallmo 1984).

The duration and distance of these annual migrations for both artiodactyl species under investigation are expected to be seen in the intra-annual variation in strontium ratio values. My goal here is not to identify the source of the animal at death, but to identify different source populations of animals. In other words, I am not attempting to source animals to specific geographic locations, but to identify the number of populations of animals being exploited by Five Finger Ridge residents. These annual migration patterns are assumed to be relatively stable interannually, with only changes in the timing of migrations that depend on local climate and resources (e.g., first snowfall, plant phenology).

Here, I test three basic hypotheses that focus on understanding the decreased abundance of *Ovis* during Period 2A and the incremental decrease in relative anatomical body parts for artiodactyls from Period 1 to Period 2B in relation to climate change, overhunting, and economic conflict.

> (1) The decrease in *Ovis* during Period 2A coincides with increases in pine over juniper and sagebrush pollen that is suggestive of a summer monsoonal pattern. This may have resulted in decreased local population densities in two ways. First, if mountain sheep were forced to higher elevations during this time, I expect there to be a shift in strontium values as previously used low-elevation winter ranges are lost and new high-elevation summer ranges are added. Thus sheep recovered from Period 2A contexts should have overlapping ranges of strontium ratio values with those of Periods 1 and 2B, but with differences in mean values resulting from a shift in maximum and minimum values.

(2) The decrease in *Ovis* occurs at the same time as an increase in summer precipitation because this climate change allowed for a greater dependence on maize horticulture. Five Finger Ridge residents may have decreased sheep hunting activities to focus instead on more locally abundant game while cultivating crops. If climate had no impact on sheep population ranges, strontium values should be indistinguishable to those from Periods 1 and 2B.

(3) Resource depression of artiodactyl species may have occurred during the occupation of Five Finger Ridge based on the decreased representation of low-utility elements through time. This pattern only suggests that transport costs shifted; whether the costs are associated with increased distances traveled or to differences in hunting strategy is unknown. If local populations were gradually reduced through hunting pressure, it is expected that additional populations of artiodactyls represented by an increased number of strontium signatures will be present in the youngest assemblages.

I will test these predictions using strontium isotope values of *Ovis* and *Odocoileus* teeth to identify the number of artiodactyl populations exploited at a given time and temporal changes that might correspond with the patterns identified in Chapter 4.

5.2 Materials and Methods

The specimens I selected for analysis are presented in Table 5.1 along with spatial context, temporal period, and age data for each individual. Mandibles of seven mountain sheep were selected based on the presence of the second and third molar in excellent condition and their association with dated contexts. In addition, I chose one specimen (8625-001) which was recovered from the undated fill of Pithouse 26 (Period 1). I selected this specimen to see whether its isotopic values could be used to align it with the dated sequence for the site. I used the second and third molar to capture the latest migration sequence recorded in the enamel for each individual.

I was unable to use the same criteria for deer specimens due to the limited number of mandibles with teeth in good condition combined with the inability to sample neonatal individuals with poorly developed enamel. The third molar (upper and lower) and permanent fourth premolars were sampled instead since these are the last teeth to erupt in *Odocoileus* (Heffelfinger 2010; Robinette et al. 1957). Although the sampling strategy is not as consistent for *Odocoileus* as for *Ovis*, each specimen represents a distinct individual based on the temporal context and age of the individual. Given the small number of *Antilocapra* mandibular specimens at Five Finger Ridge, these were excluded due to the destructive nature of this analysis.

Mountain sheep, along with other bovids, have hypsodont teeth that develop over relatively long durations of time. For *Ovis aries*, the development of the second and third molar takes approximately one and two years, respectively (Balasse et al. 2005; Weinreb and Sharav 1964). Based on similar eruption times in *O. canadensis*, it is expected that tooth formation follows approximately the same timeline. The third molar of *Odocoileus* begins to erupt around one and a half years of age and is fully erupted by two and a half years (Robinette, et al. 1957), about the same time that the deciduous fourth premolar is replaced. The dentition of *Odocoileus* represents a much more restricted period of time compared with the hypsodont teeth of *Ovis*.

I removed teeth from the mandibular body using a Dremel power tool fixed with a diamond cutting blade to cut a window through the buccal side of the lateral ramus around the second and third molar. When present, sediment locked within the alveolus was collected for analysis to determine local strontium isotope values (Table 5.1).

I chose the buccal portion of the anterior loph of M_2 and the posterior loph of M_3 since these tend to have the largest surfaces that would provide the greatest sample. These surfaces were mechanically abraded using a tungsten carbide burr to remove any adhering cementum and other potential contaminants. I then encapsulated each tooth using tape and plastic wrap with an open window around the sampling surface to prevent potential contamination from loose sediment and organic material that could not be removed through abrasion.

I followed the general serial sampling methodology used by Balasse and others (Balasse 2003; Balasse, et al. 2002; Balasse et al. 2006; Balasse, et al. 2005; Britton, et al. 2009; Zazzo, et al. 2006; Zazzo, et al. 2005). Although this method does not sample discrete growth increments, it does provide a chronological sequence of development (Balasse 2003). Each sample was removed as powder using a dental drill under magnification in bands approximately 1.0-1.5 mm thick and placed at approximately 4 mm intervals (Figure 5.2).

Each sample band was given sequential lab number starting from the cervix to the occusial end of the tooth. Depending on the individual and location of the band, the sample depth was great enough to acquire sufficient material for analysis without crossing the dentine-enamel junction.

Sample processing for strontium was conducted by Benjamin T. Valentine at clean lab facilities in the Department of Geological Sciences, University of Florida, following the same protocols listed in Valentine et al. (2008). Strontium isotopic ratios were measured using a Nu-Plasma multiple-collector inductively-coupled-plasma mass spectrometer (MC-ICP-MS). The long-term reproducibility of the TRA-measured $^{87}Sr/^{86}Sr$ of NBS 987 is 0.71024 ± 0.00005). The location, weight, and raw isotope data of each sample is provided in Appendix C.

5.3 Results

In Table 5.2, I provide descriptive statistics for each sample that demonstrate the amount of variation within and across individuals. The range of strontium ratio values for *Odocoileus* and *Ovis* (separated by temporal units) is depicted in Figure 5.3 to illustrate the dispersion of values across taxa and time.

5.3.1 Ovis

Figure 5.4 plots the strontium isotope data from the serial sampling of *Ovis* second and third lower molars. Four of the samples appear to cluster at a range of .7100 and .7110, and while they do not follow the same temporal sequence, there is generally overlap between each individual. In contrast, the three remaining samples (8304, 10249, and 8099) fall significantly below this range of strontium values. Two of the three specimens are from Period 2A.

I used a one-way ANOVA combined with Tukey's Honestly Significant Difference (HSD) test to identify whether the mean $^{87}Sr/^{86}Sr$ values are significantly different across *Ovis* individuals (Tables 5.3-5.4; Figures 5.3-5.4). As evident from Tables 5.3-5.4, the mean values of samples from Period 2A are significantly different from all Period 1 and 2B samples. Mean $^{87}Sr/^{86}Sr$ values of individuals from Period 2B are also significantly different from the values of most Period 1 individuals.

Figures 5.5-5.7 separate specimens by period to further highlight some of the differences across individual animals that cannot be seen in Figure 5.4 due to the large range in $^{87}Sr/^{86}Sr$ values. In Period 1, the mean $^{87}Sr/^{86}Sr$ values of individuals do not appear to differ significantly from one another (Table 5.4). However, based on the plots of $^{87}Sr/^{86}Sr$ values, it does not appear that the individuals sampled from this period are necessarily from the same population. Specimens 8208 and 8220 (Figures 5.8-9) show some similarities in the portion of the lower second molar that developed earliest (approximately the upper 15 mm of the tooth), but subsequently diverge. These may be individuals that shared the same geographic range for only a portion of the year, and the strontium data alone does not conclusively demonstrate that these two individuals are from distinct herd populations. Compared with these two individuals, Specimen 8225 (Figure 5.10) shows a much narrower range of variation in strontium values compared to the other two Period 1 specimens, although there is significant annual variation within this individual. This specimen probably represents an *Ovis* individual from a distinct herd group from the other Period 1 individuals.

The strontium ratio values of the two *Ovis* individuals sampled from Period 2A are not significantly different from one another. Specimen 8304 (Figure 5.11) is a relatively young individual (approximately one year old). The development of the third molar had not yet begun, and the second molar was not completely formed, limiting the number of samples taken. As such, a distance from the cervix was not possible, and the samples were measured from the base of the tooth and should be read as coming from a minimum distance from the cervix. These limitations make it difficult to compare the plots of strontium ratio values across the two individuals to determine whether they are from two separate populations (Figures 5.11-5.12). Despite this, it is clear that the Period 2A individuals are from completely different geographic ranges from all other individuals sampled.

The two samples from Period 2B both show annual variation in strontium ratio values (Figures 5.13-5.14). These ranges are distinct from one another with no overlap of values, corresponding with the significant differences found in the HSD analysis. Specimen 8099 probably represents an *Ovis* individual from a herd population distinct from all other individuals sampled. The second individual, represented by Specimen 8102, has a mean strontium ratio value that is indistinguishable from Specimen 8208 from Period 1. However, while there is clearly some overlap in strontium ratio values, there are distinct differences in the distribution of values that probably represent different migration histories.

Finally, undated Specimen 8265 provided a strontium ratio that suggests it may have been deposited during Period 2B (Table 5.2) based on its similarity to Specimen 8102. That ratio, however, also overlaps at one standard deviation with Specimen 8208 from Period 1. As a result I was unable to place this specimen in the time sequence for the site using the strontium ratio values.

5.3.2 Odocoileus

Figure 5.15 depicts the strontium ratio values for *Odocoileus*. Due to the limited number of samples per individual, migration histories cannot be evaluated. Specimen 9948 and 8687/8644 have values that overlap, and these individuals may have belonged to the same population group. The single sample from Specimen 10046 has a higher strontium ratio value, but it cannot be determined whether this individual was captured from a separate location from this data alone.

When the values for *Odocoileus* are compared with those of *Ovis*, the range of values for deer falls well within the range seen in the Period 1 and Period 2B samples. Although strontium values for the local geology are currently unknown, it is possible that deer were acquired within similar geologic ranges as mountain sheep.

5.3.3 Sediment Samples

I collected sediment locked inside the mandible of four individuals (Table 5.1). The mean strontium ratio value of the four samples after treatment with acetic acid is .7090 ± .004. This value is a reflection of the local sediment of the site, which is likely an averaging of sediments deposited by Clear Creek and its tributaries near Five Finger Ridge, including the Dry Creek and First Spring Hollow fans. The fact that these values are similar to

Specimens 10249, 8304, and 8099 is likely incidental, as it is unlikely that mountain sheep were living in the vicinity of the side considering their general leeriness of humans (e.g., Krausman et al., 1999; Shackleton 1985). Similar values may be derived from a number of geographic locations as a result of similar bedrock, weathering, and averaging of sediments, even if these locations are widely distributed. Additonal sediment or microfaunal sampling will certainly clarify the landscape of strontium ratio values and the original sources of these individuals.

5.4 Discussion

The variation in strontium values across individual life histories of mountain sheep has been shown to be sufficient to test the hypotheses set forth at the beginning of this chapter. In particular, the individuals recovered from Period 2A contexts do not appear to belong to the same populations as the other individuals, supporting the hypothesis that hunters were traveling to new locations and not simply foregoing sheep hunting in favor of maize horticulture or other economic activities. The life histories of individuals from Period 1 appear to differ but may still belong to the same population. In contrast, the two individuals from Period 2B appear to represent distinct mountain sheep populations, and may indicate that hunters were covering more geographic range than during previous periods.

The decline in mountain sheep skeletal remains in Period 2A at Five Finger Ridge corresponds with strontium ratio values unique to this temporal period. At the very least, this indicates that hunters were transporting mountain sheep from new ranges. Considering that the ranges in values have no overlap with those in Period 1, it is unlikely that these represent the same population of animals that simply shifted elevational ranges. This may indicate that the mountain sheep populations previously exploited were locally extirpated as a result of climate change or human predation.

In Chapter 4, I discovered that relative anatomical part abundances of artiodactyls decreased in evenness through time, typically taken as an indicator of increased transportation distances. In Section 5.1, I argued that local decreases in artiodactyl abundances would not only result in increased transportation costs, but also in a larger number of hunting territories, and that strontium isotope ratios would provide an independent assessment of transportation in relation to resource abundances. While recognizing the limitations of the small sample size, this hypothesis is tentative supported by these data. Period 2B is the only time when more than one population of *Ovis* was clearly being exploited.

Some *Ovis* specimens from Periods 1 and 2B (Specimens 8102, 8208, and 8220) show some overlap in strontium ratio values during portions of their life but diverge elsewhere. While modern mountain sheep are known to use the same migration routes every year (Krausman et al. 1999), it is possible that annual variation in environmental conditions resulted in altered movements across geographic territories. This may have been exacerbated by relatively rapid environmental changes that occurred at the end of the Fremont period. This would not only explain the differences in life histories of these individuals, but may also explain why some specimens (e.g., Specimen 8208) do not show symmetrical fluctuations as individuals move in altitude over the same geologic ranges from year to year that has been noted in other contexts (e.g., Balasse, et al. 2002; Britton, et al. 2009).

5.5 Conclusions

The stable strontium isotope results have successfully provide independent evidence for localize artiodactyl population fluctuations and transportation. Even if the assumptions used when making transportation inferences on the basis of anatomical parts are ignored (Bartram 1993; Lupo 2006; O'Connell, et al. 1990), I was only able to identify temporal changes in anatomical part abundances for artiodactyls as a whole. The small sample sizes of anatomical parts below this taxonomic level prevented identification of similar patterns. Despite the limitations of small samples, strontium isotopes have proven successful in this case by showing significant differences in the geologic origins of animals across temporal periods.

This study provides the beginning of a larger dataset on isotopic values for the region. As more data are collected, patterns of animal exploitation should become increasingly clear. Furthermore, future work testing sediments or small game with limited home ranges would provide necessary data for identifying the sources of large game. This cannot be done with modern artiodactyl populations as historic migration and home ranges have been affected by modernization (e.g., fencing, domestic livestock), and the current climate is not comparable to the conditions present during Fremont times. Indeed, the isotopic data presented here provide insights on otherwise unknown prehistoric animal movements. I am in the process of conducting light isotope (oxygen and carbon) analysis from the same samples used for strontium to identify how artiodactyl populations altered migration according to rapid climate change. This will provide critical data for conservation biology, especially relevant to recent efforts to reintroduce mountain sheep in the Great Basin and questions regarding their susceptibility to global warming (e.g., Epps et al., 2006).

Returning to the original predictions for costly signaling presented in Chapter 1, I expect that the apparent rarity of local mountain sheep populations during Period 2A would have increased the signaling value of this particular prey item. Unfortunately, I am unable to identify corresponding changes in the spatial distribution of mountain sheep within Five Finger Ridge due to the taphonomic issues presented in Chapter 3. With additional strontium data for the local geology, especially if obtained by sampling microfauna (Bentley 2006), it may be possible to identify the actual travel distances and transportation costs for mountain sheep from each period, and these data may show that mountain sheep were relatively costly to acquire.

Tables

Table 5.1: Specimens sampled for stable isotopes

Taxon	Specimen	Provenience	Period	Tooth	Individual Age
Odocoileus	9948-009b	Pithouse 61	2A	M^3	~ 3-5 years
	10046-002	Pithouse 62	2B	PM_4	~ 8 years
	8644-001a, 8687-001b	Pithouse 75	2B	PM_4, M_3	3.5 years
Ovis	8208-001	Pithouse 29	1	M_{2-3}	3.5 years
	8220-001	Pithouse 28	1	M_2	5+ years
	8225-001	Pithouse 28	1	M_{2-3}	4 years
	8304-001	Pithouse 5	2A	M_2	1 year
	10249-023	Activity Area 24	2A	M_{2-3}	5+ years
	8099-001	Pithouse 3	2B	M_{2-3}	4 years
	8102-001	Pithouse 3	2B	M_{2-3}	4 years
	8265-001	Pithouse 26 Fill	UNK	M_{2-3}	3.5 years
Sediment	10249-023	Activity Area 24	--	--	--
	8099-001	Pithouse 3	--	--	--
	8102-001	Pithouse 3	--	--	--
	8208-001	Pithouse 29	--	--	--

Table 5.2. Mean strontium ratio values and standard deviations for each sample tested from Five Finger Ridge.

Taxon	Specimen	Period	Mean	Std Dev.	Samples
Sediment	--	--	0.7091	0.0004	4
Ovis	8208-001	1	0.7105	0.0002	14
	8220-001	1	0.7108	0.0002	6
	8225-001	1	0.7108	0.0001	8
	10249-023	2A	0.7086	0.0006	9
	8304-001a	2A	0.7086	0.0000	3
	8099-001	2B	0.7091	0.0003	12
	8102-001	2B	0.7103	0.0002	14
	8265-001	UNK	0.7103	0.0001	9
Odocoileus	8644-001a, 8687-001b	2B	0.7102	0.0002	3
	9948-009b	2A	0.7104	0.0000	2
	10046-002	2B	0.7107	--	1

Table 5.3: One-way ANOVA comparison across *Ovis* individuals.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	**.000**	**7**	**.000**	**85.621**	**.000**
Within Groups	**.000**	**67**	**.000**		
Total	**.000**	**74**			

Table 5.4: Tukey's Honestly Significant Difference matrix of probability values for ANOVA between *Ovis* individuals.

		Period 1			**Period 2A**		**Period 2B**		**Unknown**
		8208-001	**8220-001**	**8225-001**	**10249-023**	**8304-001a**	**8099-001**	**8102-001**	**8265-001**
Period 1	**8208-001**	--	0.177	0.319	0.000	0.000	0.000	0.909	0.789
	8220-001	--	--	1.000	0.000	0.000	0.000	0.015	0.012
	8225-001	--	--	--	0.000	0.000	0.000	0.027	0.022
Period 2A	**10249-023**	--	--	--	--	1.000	0.000	0.000	0.000
	8304-001a	--	--	--	--	--	0.054	0.000	0.000
Period 2B	**8099-001**	--	--	--	--	--	--	0.000	0.000
	8102-001	--	--	--	--	--	--	--	1.000
Unknown	**8265-001**	--	--	--	--	--	--	--	--

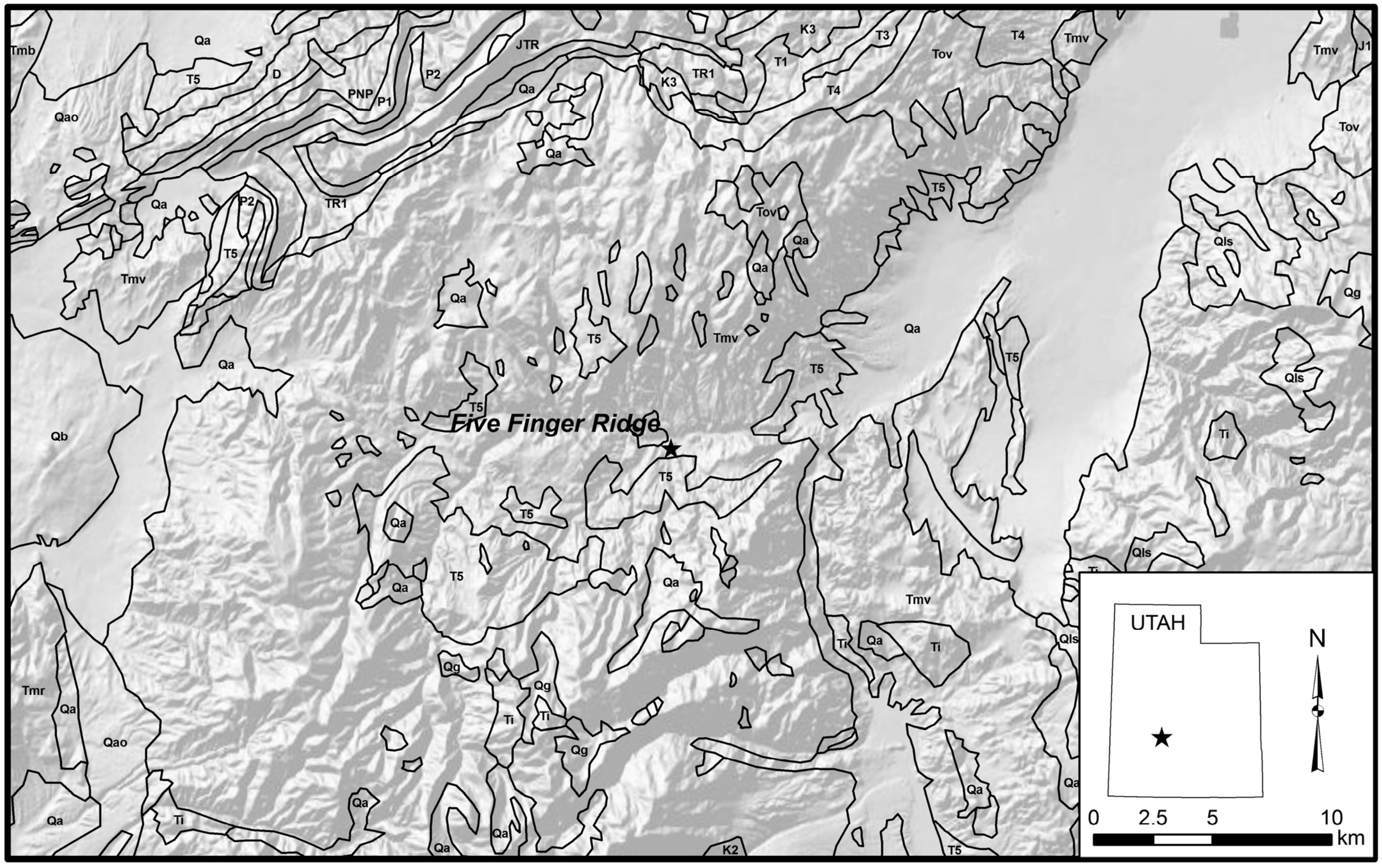


Figure 5.1: Map of geologic formations in the vicinity of Five Finger Ridge. K3 = Cretaceous (Price River Formation); P1 = Permian (Diamond Creek Sandstone, Kirkman Limestone); P2 = Permian (Park City and Phosphoria Formations); Qa = Quarternary (alluvium and colluviums); Qao = Quaternary (older alluvial deposits); Qb = Quaternary (basalts); T1 = Paleocene (Claron Formation); T4 = Miocene (Muddy Creek Formation); T5 = Miocene-Pliocene (Sevier River Formation); Ti = Oligocene (Quartz Monzonite); Tmv = Miocene-Pliocene (Silver Shield Latite, Pinyon Creek Conglomerate); Tov =Oligocene (Laguna Springs Latite, Tintic Mountain Group, Packard Quartz Latite).

Figure 5.2: Serial sampling bands on Specimen 8102 (*Ovis*, Period 2B). Left: Lower second molar; right: lower third molar. Scale = 1 cm.

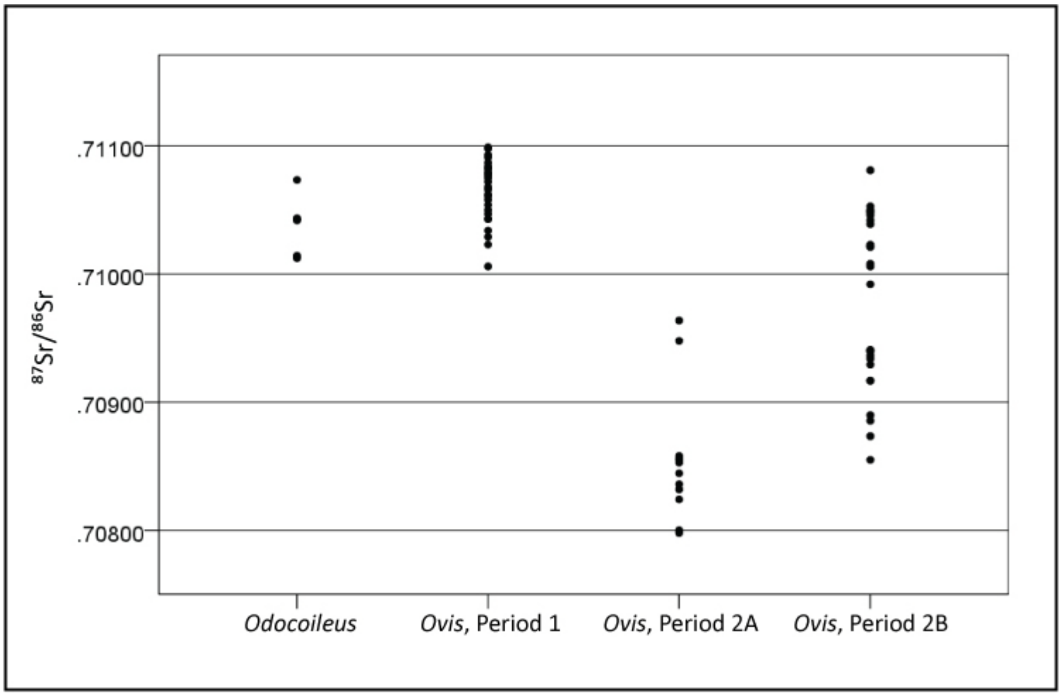


Figure 5.3: Distribution of strontium ratio values across taxa and temporal periods (*Ovis*)

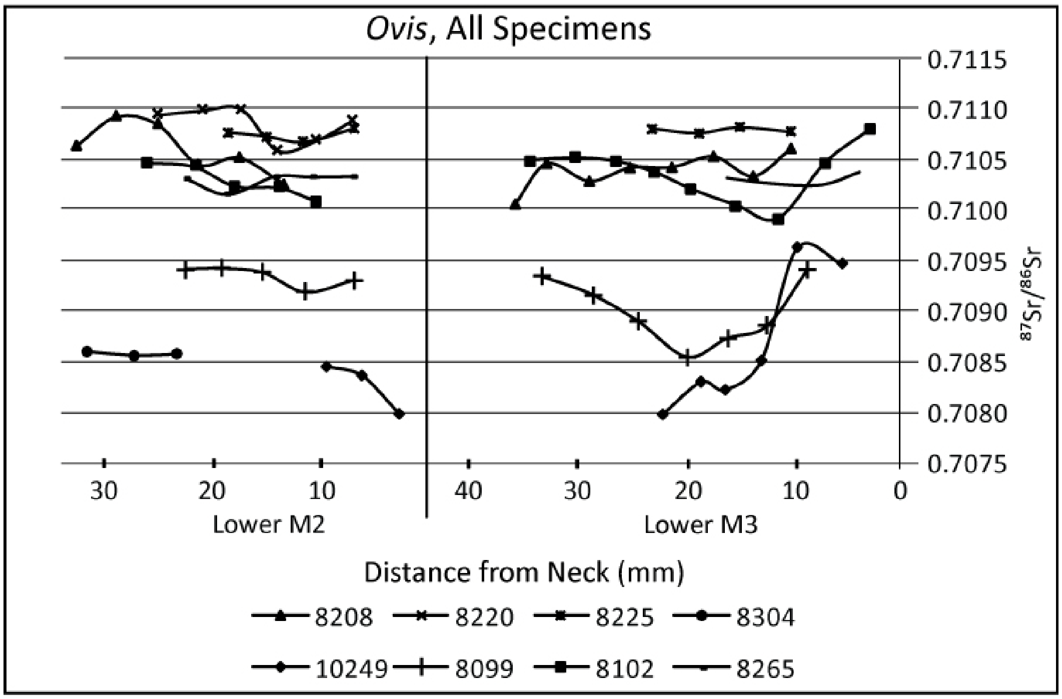


Figure 5.4: Plot of strontium ratio values for all *Ovis* individuals.

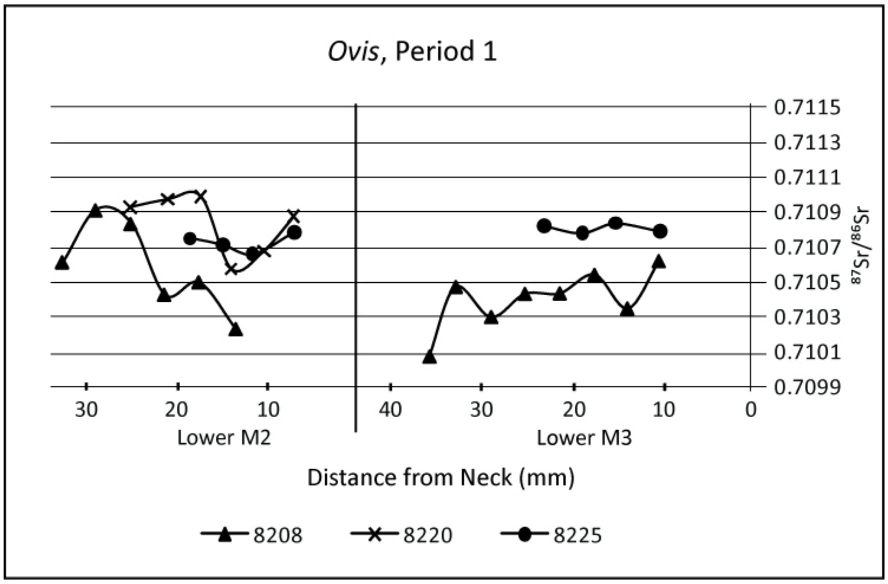


Figure 5.5: Plot of *Ovis* strontium ratio values for Period 1 individuals.

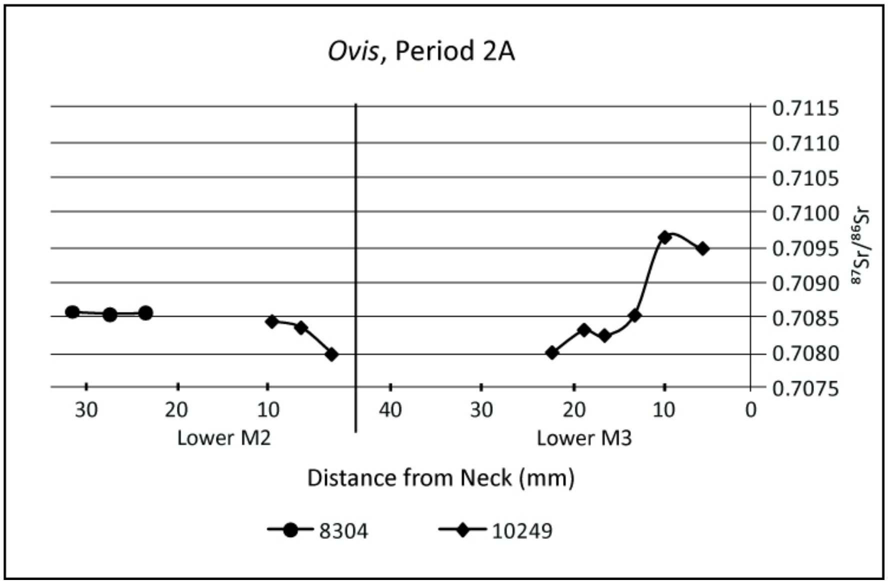


Figure 5.6: Plot of Ovis strontium ratio values for Period 2A individuals.

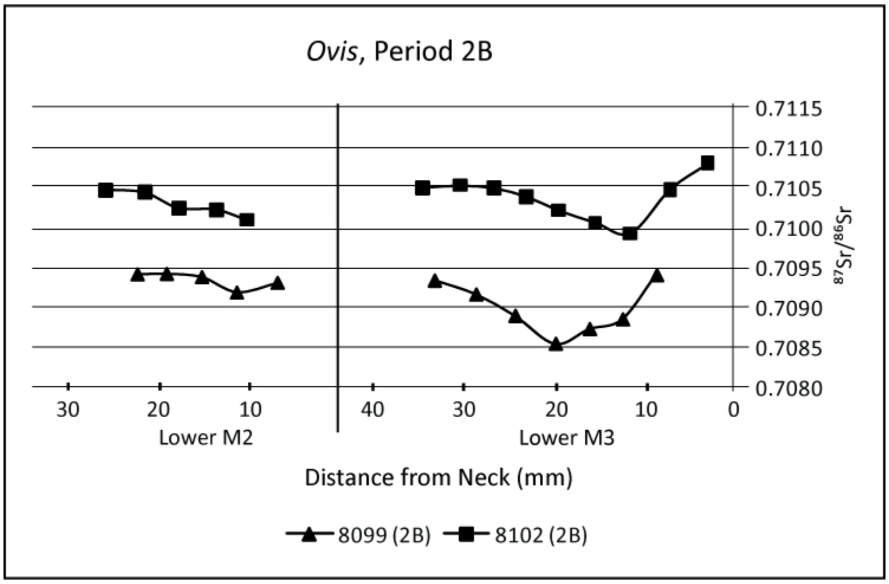


Figure 5.7: Plot of Ovis strontium ratio values for Period 2B individuals.

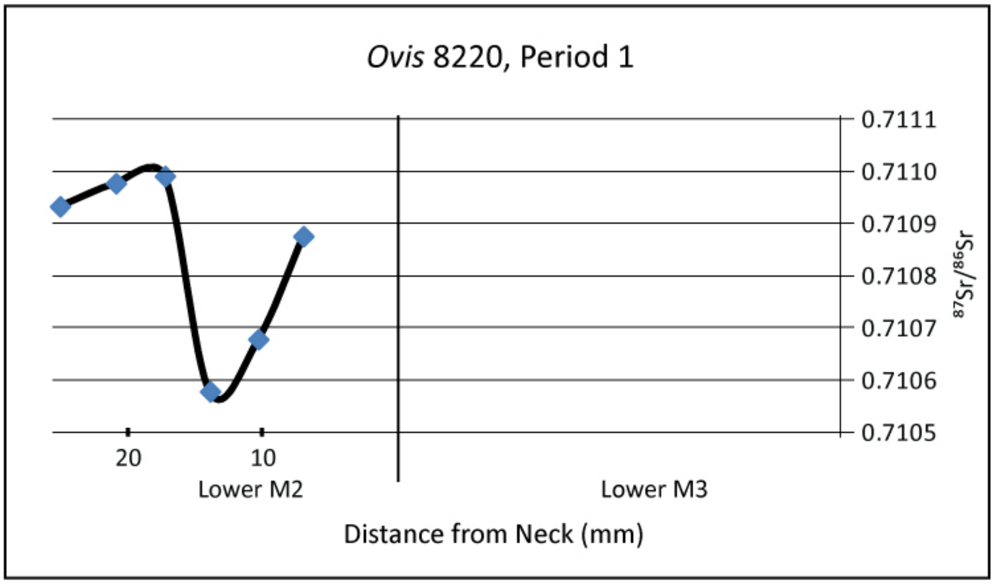


Figure 5.8: Plot of strontium ratio values for Specimen 8220.

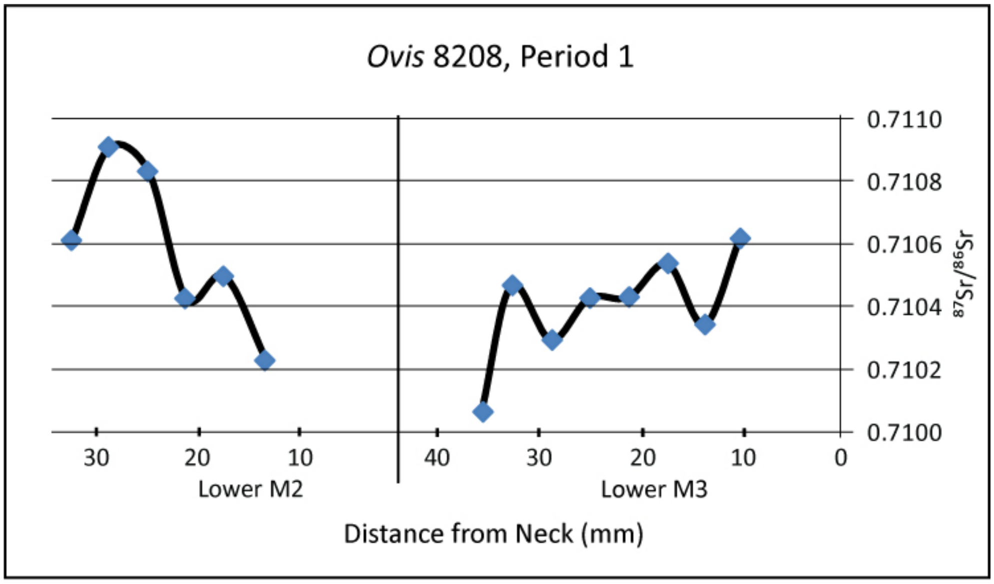


Figure 5.9: Plot of strontium ratio values for Specimen 8208.

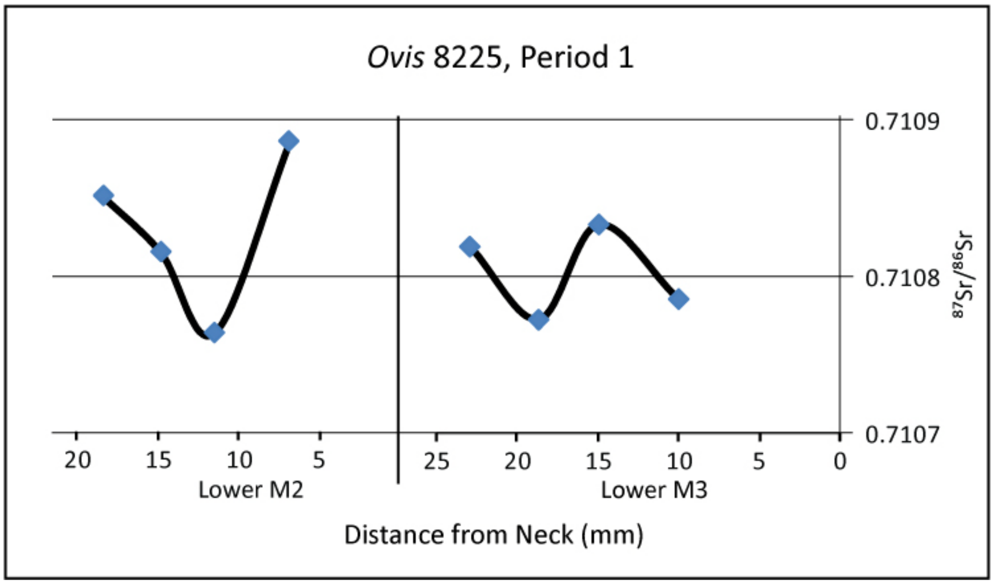


Figure 5.10: Plot of strontium ratio values for Specimen 8225.

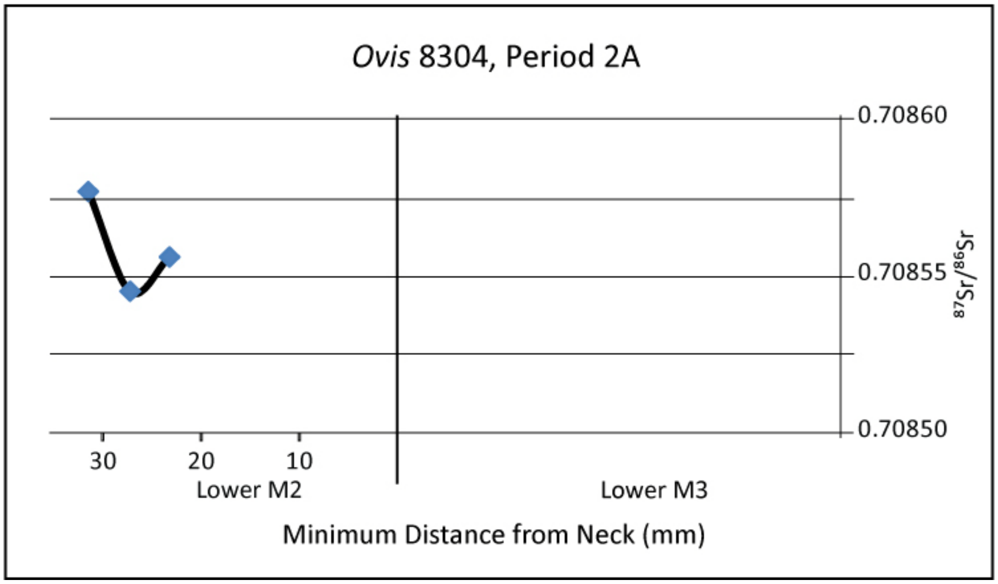


Figure 5.11: Plot of strontium ratio values for Specimen 8304.

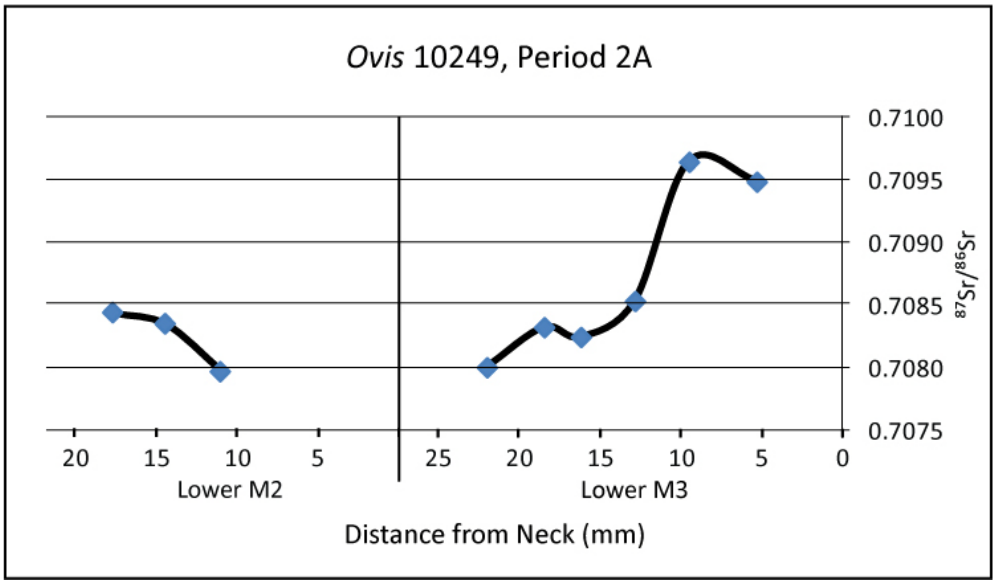


Figure 5.12: Plot of strontium ratio values for Specimen 10249.

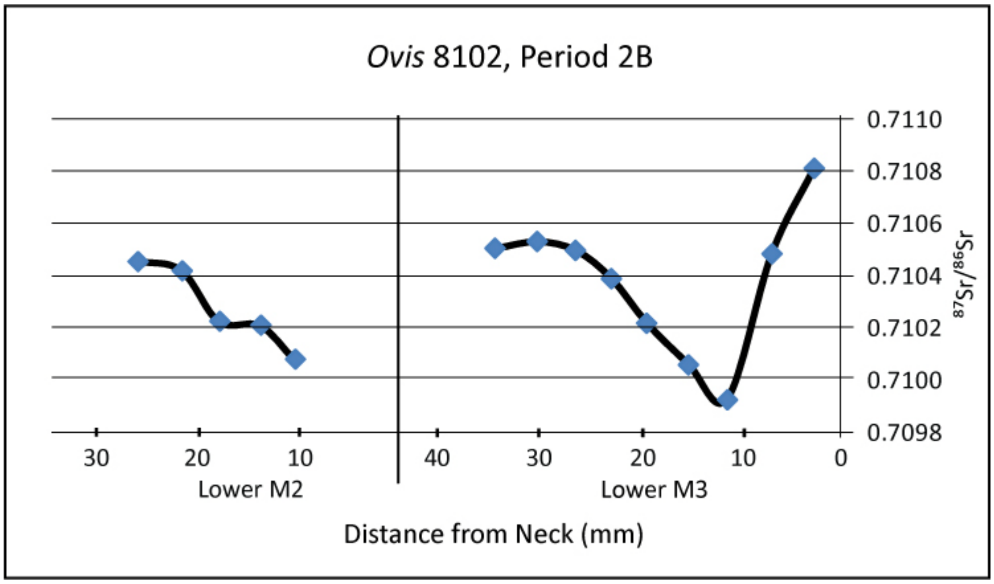


Figure 5.13: Plot of strontium ratio values for Specimen 8102.

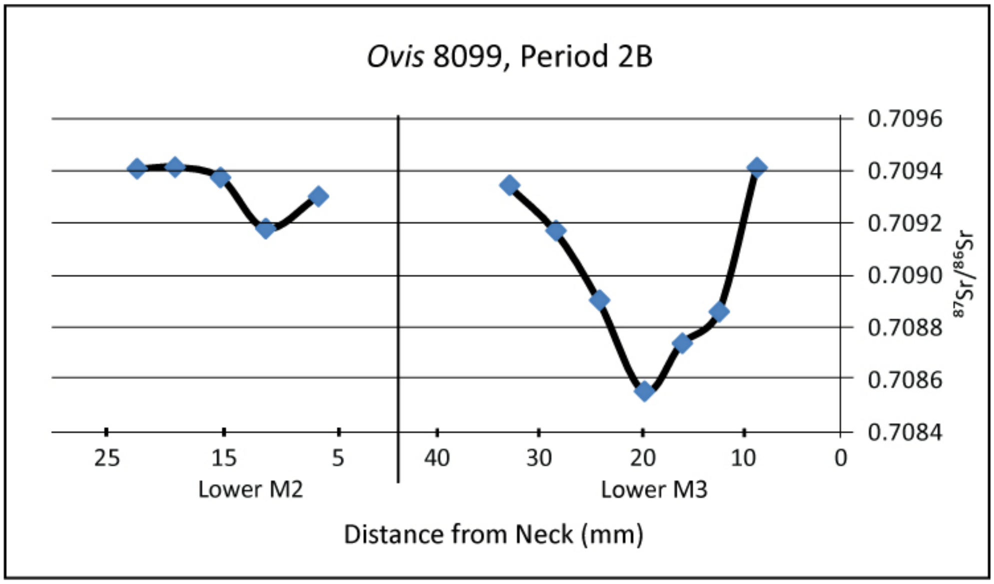


Figure 5.14: Plot of strontium ratio values for Specimen 8099.

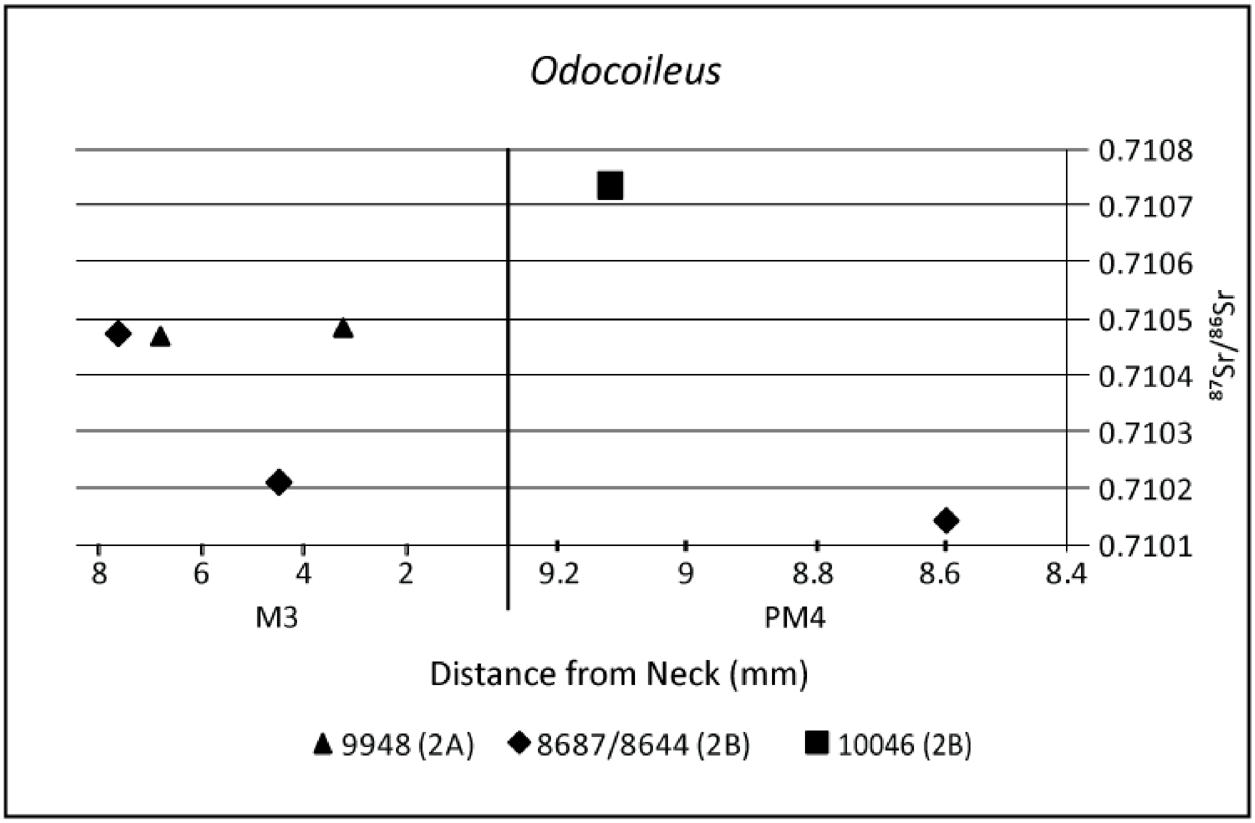


Figure 5.15: Strontium ratio values for *Odocoileus*. Specimen 9948 is the upper third molar; all other specimens are mandibular teeth.

Chapter 6

CONCLUSIONS

6.1 Summary of Results

My dissertation research sought to tackle the on-going debate regarding the presence of costly signaling forms of hunting among prehistoric hunter-gatherers in western North America (Broughton and Bayham 2003; Codding and Jones 2007; Grimstead 2010; Hildebrandt and McGuire 2002, 2003; Hockett 2005; McGuire and Hildebrandt 2005; McGuire et al. 2007). Specifically, I argued that hunters motivated by signaling behaviors should select prey in ways not predicted by optimal foraging models, but instead target animals with high variance of success resulting from defense behaviors, hunting methods, and rarity on the landscape. "Good" hunters that carry some underlying trait desirable by others but that cannot be directly observed should have a higher rate of hunting success for these species. An audience of observers for this signal is in part created by widespread, indiscriminate sharing of captured animals.

I took two approaches to detecting costly signaling hunting in the archaeological record. First, I argued that decreased local population levels of some animals, especially large game, will result in increased search and travel costs. Such animals that were once valued for their high net energy return would be specifically targeted by signaling hunters. Second, indiscriminate sharing of these animals may be identified through the analysis of inter-household distribution of faunal remains. If the signaling value of a species changes through time, the distribution of the animal across a site should change accordingly. I used the fauna from Five Finger Ridge, a Fremont site located in Central Utah, due to the large number of archaeological households and demonstrated changes in resource availability in the region (Janetksi 1997; Janetski, et al. 2000; Talbot et al. 2000).

I began this analysis by evaluating whether the Five Finger Ridge assemblage had been detrimentally altered by post-depositional processes. Analysis of density-mediated destruction has become a standard practice in zooarchaeology, but it had yet to be applied to questions regarding household foraging economies and sharing. I discovered that the spatial distribution of fauna and their skeletal parts is largely determined by complex taphonomic histories. The degree of density-mediated destruction varies according to site context and taxon, to such a degree that spatial differences in taxonomic frequencies and their skeletal parts cannot be attributed to human behavior alone. This is not to say that sharing of animal resources cannot be identified archaeologically, but that my tests using taxonomic and skeletal part evenness and richness could not be applied to the Five Finger Ridge assemblage.

In Chapter 4, I identified a number of changes in local faunal exploitation that reflect fluctuating climate conditions and human hunting pressure over a period of roughly two hundred years at Five Finger Ridge. The location of the site near the current elevational boundary of Nuttall's (*Sylvilagus nuttallii*) and the desert (*S. audubonii*) cottontail rabbit allowed the identification of shifting relative abundances of these two species during the occupation of the site at the end of the Fremont period. The shift from *S. audubonii* to *S. nuttallii* occurs at the same time that jackrabbits (*Lepus* sp.) become less abundant. This shift in leporid frequencies is likely a reflection of changing vegetation regimes in the vicinity of the site, one that consisted of a more closed landscape that was less favorable for desert cottontails and jackrabbits.

Unfortunately, the variability in density-mediated destruction and its relationship with the Artiodactyl Index prohibited analysis of changing diet breadth according to the local abundances of high ranked prey, typically artiodactyls. Nonetheless, I did discover that the relative abundances of anatomical body parts gradually change for artiodactyls as a whole during the occupation of the site. In particular, low-utility body parts become less abundant, suggesting that associated transport costs increased toward the end of the site occupation. Period 2B also witnessed an increase in pronghorn (*Antilocapra americana*), a species that was most likely acquired in the valleys to the east or west of Clear Creek Canyon, supporting the argument that hunters increasingly used distant resources. I also discovered that mountain sheep (*Ovis canadensis*) are significantly underrepresented in the Period 2A assemblage, corresponding with increased summer precipitation.

I used strontium isotope ratios as an independent measure to determine whether hunters were traveling to more distant localities as a response to locally reduced artiodactyl populations. The isotopic signatures of dentition from two sheep individuals from this period reveal that hunters were acquiring sheep from different locations than in Periods 1 and 2B. Collectively, the decreased abundance of sheep, the decrease in abundance of artiodactyls low-utility body parts, and the strontium isotope data indicate local sheep populations were most probably reduced by climate change, and hunters were traveling to new locations.

The data on changing artiodactyl abundances, anatomical body parts, and strontium isotopes cannot be used to conclusively demonstrate that artiodactyls increased in signaling value alone. My original objective of identifying corresponding changes in sharing behaviors was not possible, and additional evidence is necessary to show that the associated costs of traveling further abroad were exceptionally high compared to the return rates. This may be accomplished by sampling modern microfauna in the region to identify biologically-available strontium isotope ratio values (Bentley 2006).

6.2 Archaeological Contributions

Although my original objective, to identify costly signaling forms of hunting, could not be addressed, this research project has provided a number of methodological and empirical contributions. I have extended the use of bone attrition analysis to address new questions regarding the variability of density-mediated destruction across site contexts and species. Indeed, the analysis of density-mediated destruction at Five Finger Ridge serves as an important cautionary tale. Over the past few decades, archaeologists have been using taxonomic diversity measures to test hypotheses formed from optimal foraging theory without considering the possibility that different taxa may have distinct taphonomic histories that impact their survivorship (see Ugan 2005 for an exception). Here, I have shown that the Artiodactyl Index at Five Finger Ridge is largely explained by density-mediated destruction and cannot be taken as an accurate reflection of foraging behavior. This finding demonstrates the importance of accounting for variation in density-mediated destruction among multiple species before any human behavioral inferences are formed from taxonomic diversity measures.

Although widely used by bioarchaeologists and zooarchaeologists working with domesticated animals, the use of strontium for identifying changes in the origin of prey populations is still in its infancy (e.g., Britton et al. 2009; Grimstead and Reynolds 2008; Hedman et al. 2009). The successful use of strontium isotopes to show shifting use of the landscape by foragers illustrates that this method holds much promise for hunter-gatherer archaeology, overcoming the methodological issues inherent when using archaeological fauna for inferring local prey abundances and transportation.

6.3 Paleoenvironmental Contributions

The Five Finger Ridge dataset provides important data on mammalian responses to climate change that may prove essential for understanding the biogeography of some species and their responses to future climate change. Although other archaeologists have used the relative abundance of jackrabbits to cottontail rabbits to identify changes in the landscape resulting from climate and horticultural activities (e.g., Fisher and Johnson submitted; Quirt-Booth and Cruz-Uribe 1997; Szuter 1991; Szuter and Bayham 1989), I had the opportunity to identify temporal changes in the relative abundance of two cottontail species (*S. audubonii* and *S. nuttallii*). Although local pollen records show altering climate conditions at the end of the Fremont Period (Newman 2000), faunal responses to these changes in this area have been limited to a handful of species (Grayson 2006a, b; Grayson and Fisher 2009).

The strontium data also provides some insights into mountain sheep responses to climate change. Serial sampling of teeth provides data on annual variations in migration history and potentially climate (especially if coupled with light isotopes) that is unavailable from most other paleoenvironment records. Some *Ovis* individuals at Five Finger Ridge appear to have changed migration routes during their first years of life. Current populations of mountain sheep are known to follow the same migration route from year to year, with minor changes in the timing of movements dictated by annual variation in climate, generally the first snowfall (Krausman et al. 1999). The possibility that some individuals did not revisit the same migration route in consecutive years suggests that there may have been strong interannual fluctuations in climate at the end of the Fremont period. I have begun analysis using stable oxygen isotopes to identify whether precipitation and temperature varied rapidly during the early life of some individuals.

The decline in mountain sheep during Period 2A corresponds with increased summer precipitation. The fact that the strontium isotope signatures for sheep at this time are significantly different from those of the previous period suggests that new hunting localities were being used by Five Finger Ridge hunters. The lack of overlap in strontium values with those in Period 1 suggests that this was not simply an elevational change of mountain sheep populations as a response to climate change. Recent research suggests that climatic warming plays a significant role in the twentieth-century extirpations of mountain sheep in southeastern California (Bailey 1980; Epps et al. 2004; Epps et al. 2006), and it is possible that there was a similar loss of local populations surrounding Five Finger Ridge during Period 2A. Future work using ancient DNA may be able to address this issue by identifying whether hunters were acquiring animals from the same genetic population but from different geographic sources.

6.4 The Future of Costly Signaling in Hunter-Gatherer Archaeology

In 2007, McGuire et al. cautioned against positioning costly signaling theory as "no-can-do" archaeology. While archaeologists may not be able identify specific conditions for costly signaling, they argue that we must find innovative ways for identifying the full range of human behavior from the prehistoric record. Although my attempt to broaden our understanding of past human behavior was prevented by complications arising from the complexities of post-depositional processes at Five Finger Ridge, by no means should this research be taken as support for the "no-can-do" attitude. New, creative approaches must be designed to overcome such obstacles.

On one hand, future research should continue efforts for identifying costly signaling prehistorically. This is necessary before we are able to use the archaeological record to its fullest potential, such as identifying conditions when costly signaling forms of hunting are intensified, as well as the role of hunting motivations in cultural change, domestication, and other processes. Given the issues encountered here for identifying meaningful distributions of fauna between archaeological houses, it may be fruitful to identify other ways audience formation may leave archaeological traces. Feasting activities may be particularly interesting since both male and female signaling may occur in such contexts. Future work looking at changes in the kinds of animals used in feasts, how they are prepared for food, and how they are presented may provide some insights on costly signaling within subsistence activities. In western North America, such research might aid our understanding of the evolution of communal jackrabbit and pronghorn drives as both a foraging and social activity, especially considering recent research that has demonstrated the potentially high costs of conducting such drives (Ugan 2005b).

Additional bioarchaeological work may provide the necessary analytical unit of the individual for expanding research in costly signaling. In line with the approach taken here, it may be particularly worthwhile to evaluate the distribution of certain skeletal markers in a population with the expectation that some men would have higher levels of osteoarthritis related to long distance traveling (e.g., Larson et al. 1995).

Once we identify ways to identify costly signaling forms of hunting, we will be able to evaluate the conditions that would lead to such hunting to become more or less important in the archaeological record. Here, I have focused on identifying how particular animals may be targeted by signaling hunters, with the assumption that signaling forms of hunting would be present regardless of context. For example, while the predictions have yet to be formulated, I would expect signaling forms of hunting may be more important in groups exhibiting matrilocality. This may be investigated by measuring strontium ratio values of bone and teeth of men to infer potential exogamy patterns, as significantly different strontium ratio values in the recently formed bone from tooth enamel formed during childhood would be an indicator that the individual left his or her birth group. Similarly, future research should also evaluate temporal changes in the intensity of signaling hunting according to possible changes in sexual division of labor, with the expectation that increased independence of foraging between the sexes would diminish the utility of signaling hunting.

It may be particularly fruitful to link costly signaling arguments for hunting to behaviors noted in human societies that have limited hunting capacities. What happens when foraging tasks become less defined by the sexual division of labor? What happens during the shift from foraging to full-time agricultural pursuits? Answering such questions will provide a greater understanding of patterns of change in the human past.

REFERENCES

Allen-Arave, W., M. Gurven and K. Hill

2008 Reciprocal altruism, rather than kin selection, maintains nepotistic food transfers on an Ache reservation. *Evolution and Human Behavior* 29(5):305-318.

Allred, L. G., L. R. Baker and W. G. Bradley

1966 Additional Studies of Anomalies of the Skull in Desert Bighorn Sheep. *Transactions of California-Nevada Section of the Wildlife Society* 1:75-81.

Anderson, A. E., D. E. Medin and D. C. Bowden

1974 Growth and Morphometry of the Carcass, Selected Bones, Organs, and Glands of Mule Deer. *Wildlife Monographs* (39):3-122.

Anderson, A. E. and O. C. Wallmo

1984 Odocoileus hemionus. *Mammalian Species* (219):1-9.

Bailey, J. A.

1980 Desert Bighorn, Forage Competition, and Zoogeography. *Wildlife Society Bulletin* 8(3):208-216.

Balasse, M.

2003 Potential biases in sampling design and interpretation of intra-tooth isotope analysis. *International Journal Of Osteoarchaeology* 13(1-2):3-10.

Balasse, M., S. H. Ambrose, A. B. Smith and T. D. Rpice

2002 The seasonal mobility model for prehistoric herders in the South-western Cape of South Africa assessed by isotopic analysis of sheep tooth enamel. *Journal of Archaeological Science* 29(9):917-932.

Balasse, M., A. Tresset and S. H. Ambrose

2006 Stable isotope evidence (delta C-13, delta O-18) for winter feeding on seaweed by Neolithic sheep of Scotland. *Journal of Zoology* 270(1):170-176.

Balasse, M., A. Tresset, K. Dobney and S. H. Ambrose

2005 The use of isotope ratios to test for seaweed eating in sheep. *Journal of Zoology* 266:283-291.

Barlow, K. R.

2006 A Formal Model for Predicting Agriculture among the Fremont. In *Behavioral ecology and the transition to agriculture*, edited by D. J. Kennett and B. Winterhalder, pp. 87-102. University of California Press, Berkeley.

Barone, R. and R. Bortolami

1996 *Anatomie comparée des mammifères domestiques: Tome 6, Neurologie I, système nerveux central*. Vigot.

Bartram, L. E.

1993 Perspectives on Skeletal Part Profiles and Utility Curves from Eastern Kalahari Ethnoarchaeology. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 115-137. Center for Archaeological Investigations Occassional Paper 21.

Beck, C., A. K. Taylor, G. T. Jones, C. M. Fadem, C. R. Cook and S. A. Millward

2002 Rocks are heavy: transport costs and Paleoarchaic quarry behavior in the Great Basin. *Journal of Anthropological Archaeology* 21(4):481-507.

Behrensmeyer, A. K.

1978 Taphonomic and ecologic information from bone weathering. *Paleobiology* 4(2):150-162.

Behrensmeyer, A. K., K. D. Gordon and G. T. Yanagi

1986 Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature* 319(6056):768-771.

Belk, M. C. and H. D. Smith

1991 Ammospermophilus leucurus. *Mammalian Species* 368:1-8.

Benson, L., M. Kashgarian, R. Rye, S. Lund, F. Paillet, J. Smoot, C. Kester, S. Mensing, D. Meko and S. Lindstrom

2002 Holocene multidecadal and multicentennial droughts affecting Northern California and Nevada. *Quaternary Science Reviews* 21(4-6):659-682.

Benson, L. V., E. M. Hattori, H. E. Taylor, S. R. Poulson and E. A. Jolie

2006 Isotope sourcing of prehistoric willow and tule textiles recovered from western Great Basin rock shelters and caves - proof of concept. *Journal of Archaeological Science* 33(11):1588-1599.

Bentley, R. A.

2006 Strontium isotopes from the earth to the archaeological skeleton: A review. *Journal of Archaeological Method and Theory* 13(3):135-187.

Bentley, R. A., T. D. Price and E. Stephan

2004 Determining the 'local' Sr-87/Sr-86 range for archaeological skeletons: a case study from Neolithic Europe. *Journal of Archaeological Science* 31(4):365-375.

Berry, M. S.
1980 Fremont Origins: A Critique. In *Fremont perspectives*, edited by D. B. Madsen, pp. 17-24. Antiquities Section Selected Papers. vol. Volume VII, Number 16. Utah State Historical Society, Salt Lake City.

Bettinger, R. L., R. Malhi and H. McCarthy
1997 Central place models of acorn and mussel processing. *Journal of Archaeological Science* 24(10):887-899.

Binford, L. R.
1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.

1981 *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

Bird, D. and J. O'Connell
2006 Behavioral Ecology and Archaeology. *Journal of archaeological research* 14(2):143.

Bird, D. W. and R. Bliege Bird
2000 The ethnoarchaeology of juvenile foragers: Shellfishing strategies among Meriam children. *Journal of Anthropological Archaeology* 19(4):461-476.

Bird, D. W., J. L. Richardson, P. M. Veth and A. J. Barham
2002 Explaining shellfish variability in middens on the Meriam Islands, Torres Strait, Australia. *Journal of Archaeological Science* 29(5):457-469.

Bird, R.
1999 Cooperation and conflict: The behavioral ecology of the sexual division of labor. *Evolutionary Anthropology* 8(2):65-75.

Bird, R. B., B. F. Codding and D. W. Bird
2009 What Explains Differences in Men's and Women's Production? *Human Nature-an Interdisciplinary Biosocial Perspective* 20(2):105-129.

Bird, R. B. and E. A. Smith
2005 Signaling theory, strategic interaction, and symbolic capital. *Current Anthropology* 46(2):221.

Bliege Bird, R., D. W. Bird, E. A. Smith and G. C. Kushnick
2002 Risk and reciprocity in Meriam food sharing. *Evolution and Human Behavior* 23(4):297-321.

Bliege Bird, R. and E. A. Smith

2005 Signaling theory, strategic interaction, and symbolic capital. *Current Anthropology* 46(2):221.

Bliege Bird, R., E. A. Smith and D. W. Bird
2001 The hunting handicap: costly signaling in human foraging strategies. *Behavioral Ecology and Sociobiology* 50(1):9-19.

Blumenschine, R. J. and C. W. Marean
1993 A carnivore's view of archaeological bone assemblages. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Blumenschine, R. J., C. W. Marean and S. D. Capaldo
1996 Blind tests of inter-analyst correspondence and accuracy in the identification of cut marks, percussion marks, and carnivore tooth marks on bone surfaces. *Journal of Archaeological Science* 23(4):493-507.

Bradley, W. G. and L. G. Allred
1966 A comparative study of dental anomalies in Desert Bighorn Sheep. In *Desert Bighorn Council 1966 Transactions*, edited by J. Yoakum, C. Hansen, N. Simmons, W. Graf and R. Brechbill. Desert Bighorn Council, Las Vegas, Nevada.

Brain, C. K.
1981 *The Hunters or the Hunted? An Introduction to African Cave Taphonomy*. University of Chicago Press, Chicago.

Britton, K., V. Grimes, J. Dau and M. P. Richards
2009 Reconstructing faunal migrations using intra-tooth sampling and strontium and oxygen isotope analyses: a case study of modern caribou (Rangifer tarandus granti). *Journal of Archaeological Science* 36(5):1163-1172.

Brook, B. W. and D. Bowman
2005 One equation fits overkill: why allometry underpins both prehistoric and modern body size-biased extinctions. *Population Ecology* 47(2):137-141.

Broughton, J. M.
1994a Declines in Mammalian Foraging Efficiency During the Late Holocene, San-Francisco Bay, California. *Journal of Anthropological Archaeology* 13(4):371-401.

1994b Late Holocene resource intensification in the Sacramento Valley, California: the vertebrate evidence. *Journal of Archaeological Science* 21(4):501-514.

1997 Widening diet breadth, declining foraging efficiency, and prehistoric harvest pressure: ichthyofaunal evidence hem the Emeryville Shellmound, California. *Antiquity* 71(274):845-862.

2001 Resource intensification and late Holocene human impacts on Pacific Coast bird populations: evidence from the Emeryville Shellmound avifauna. *Posing questions for a scientific archaeology*:251-278.

2002 Prey spatial structure and behavior affect archaeological tests of optimal foraging models: examples from the Emeryville Shellmound vertebrate fauna. *World Archaeology* 34(1):60-83.

Broughton, J. M. and F. E. Bayham
2003 Showing off, foraging models, and the ascendance of large-game hunting in the California Middle Archaic. *American Antiquity* 68(4):783-789.

Broughton, J. M. and D. K. Grayson
1993 Diet Breadth, Adaptive Change, and the White Mountains Faunas. *Journal of Archaeological Science* 20(3):331-336.

Brown, J. K.
1970 A Note on the Division of Labor by Sex. *American Anthropologist* 72(5):1073-1078.

Butler, V. L.
2000 Resource depression on the Northwest Coast of North America. *Antiquity* 74(285):649-661.

Butler, V. L. and S. K. Campbell
2004 Resource intensification and resource depression in the Pacific Northwest of North America: A zooarchaeological review. *Journal of World Prehistory* 18(4):327-405.

Byers, D. A. and J. M. Broughton
2004 Holocene environmental change, artiodactyl abundances, and human hunting strategies in the Great Basin. *American Antiquity* 69(2):235-255.

Cameron, C. M.
1990 Pit structure abandonment in the 4 corners region of the American Southwest--Late Basketmaker III and Pueblo I periods. *Journal Of Field Archaeology* 17(1):27-37.

Cannon, M. D.

2000 Large mammal relative abundance in Pithouse and Pueblo period archaeofaunas from southwestern New Mexico: Resource depression among the Mimbres-Mogollon? *Journal of Anthropological Archaeology* 19(3):317-347.

2001 Large Mammal Resource Depression and Agricultural Intensification: An Empirical Test in the Mimbres Valley, New Mexico. Dissertation, Anthropology, University of Washington, Seattle.

Chaber, A.-L., S. Allebone-Webb, Y. Lignereux, A. A. Cunningham and J. M. Rowcliffe
2010 The scale of illegal meat importation from Africa to Europe via Paris. *Conservation Letters*:1-7.

Chambers, A. L.
1992 Seal bone mineral density : its effect on specimen survival in archaeological sites.

Chapman, J. A.
1975 Sylvilagus nuttallii. *Mammalian Species* (56):1-3.

Chapman, J. A. and G. R. Willner
1978 Sylvilagus audubonii. *Mammalian Species* (106):1-4.

Charles, R.
1997 Exploitation of carnivores and other fur-bearing mammals during the north-western Europe late Upper Palaeolithic and Mesolithic. *Oxford Journal of Archaeology* 16(3):253-277.

Church, R. R. and R. L. Lyman
2003 Small fragments make small differences in efficiency when rendering grease from fractured artiodactyl bones by boiling. *Journal of Archaeological Science* 30(8):1077-1084.

Codding, B. F. and T. L. Jones
2007 Man the showoff? Or the ascendance of a just-so-story: a comment on recent applications of costly signaling theory in American archaeology. *American Antiquity* 72(2):349-358.

Coltrain, J. B. and S. W. Leavitt
2002 Climate and diet in Fremont prehistory: Economic variability and abandonment of maize agriculture in the Great Salt Lake Basin. *American Antiquity* 67(3):453-485.

Coltrain, J. B. and T. W. J. Stafford

1999 Stable Carbon Isotopes and Great Salt Lake Wetlands Diet: Toward an Understanding of the Great Basin Formative. In *Prehistoric lifeways in the Great Basin wetlands : bioarchaeological reconstruction and interpretation*, edited by B. E. Hemphill and C. S. Larsen. University of Utah Press, Salt Lake City.

Cronk, L.

1991 Human Behavioral Ecology. *Annual Review of Anthropology* 20:25-53.

Dalley, G. F.

1973 Worked bone and antler. In *Median Village and Fremont culture regional variation*, edited by J. P. Marwitt, pp. xiii, 193. University of Utah Anthropological Papers Number 95. University of Utah Press, Salt Lake City,.

Dalquest, W. W., F. B. Stangl, Jr. and J. V. Grimes

1989 The Third Lower Premolar of the Cottontail, Genus Sylvilagus, and Its Value in the Discrimination of Three Species. *American Midland Naturalist* 121(2):293-301.

Daniels, P. S.

2009 A gendered model of prehistoric resource depression : a case study on the northwest coast of North America.

Durrant, S. D.

1952 *Mammals of Utah, Taxonomy and Distribution*. University of Kansas, Lawrence.

Elbroch, M.

2006 *Animal Skulls: A Guide to North American Species*. Stackpole Books, Mechanicsburg, PA.

Elkin, D. C.

1995 Volume density of South American camelid skeletal parts. *International Journal Of Osteoarchaeology* 5(1):29-37.

Enloe, J. G.

1991 Subsistence organization in the Upper Paleolithic: Carcass refitting and food sharing at Pincevent. Dissertation, Anthropology, University of New Mexico.

2003 Food sharing past and present: archaeological evidence for economic and social interactions. *Before Farming* 1(1):1-23.

2004 Hunter-Gatherer Food Sharing: Social and Economic Interactions. In *Hunters and Gatherers in Theory and Archaeology*, edited by G. M. Crothers, pp. 211-240.

Occasional Paper No. 31. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Enloe, J. G., F. David and T. S. Hare
1994 Patterns of Faunal Processing at Section-27 of Pincevent - the Use of Spatial-Analysis and Ethnoarchaeological Data in the Interpretation of Archaeological Site Structure. *Journal of Anthropological Archaeology* 13(2):105-124.

Epps, C. W., D. R. McCullough, J. D. Wehausen, V. C. Bleich and J. L. Rechel
2004 Effects of climate change on population persistence of desert-dwelling mountain sheep in California. *Conservation Biology* 18(1):102-113.

Epps, C. W., P. J. Palsboll, J. D. Wehausen, G. K. Roderick and D. R. McCullough
2006 Elevation and connectivity define genetic refugia for mountain sheep as climate warms. *Molecular Ecology* 15(14):4295-4302.

Faith, J. T. and A. D. Gordon
2007 Skeletal element abundances in archaeofaunal assemblages: economic utility, sample size, and assessment of carcass transport strategies. *Journal of Archaeological Science*.

Fisher, J.
1995 Bone surface modifications in zooarchaeology. *Journal of Archaeological Method and Theory* 2(1):7-68.

Fisher, J. L. and K. L. Johnson
Submitted Culinary Processing of Jackrabbits at Antelope Cave, Arizona. *Journal of Anthropological Archaeology*.

Ford, P. J.
1990 Antelope, Deer, Bighorn Sheep, and Mountain Goats: A guide to the carpals. *Journal of Ethnobiology* 10(2):169-181.

Garfinkel, A. P., D. A. Young and R. M. Yohe Ii
2010 Bighorn hunting, resource depression, and rock art in the Coso Range, eastern California: a computer simulation model. *Journal of Archaeological Science* 37(1):42-51.

Gilbert, B. M.
1980 Definitive Characteristics Separating Ungulate Genera. In *Mammalian osteology*. B.M. Gilbert, Laramie, Wyo. (709 Kearney, Laramie, Wyo. 82070).

Gilman, P. A.

1987 Architecture as artifact--pit structures and pueblos in the American Southwest. *American Antiquity* 52(3):538-564.

Gintis, H., E. A. Smith and S. Bowles

2001 Costly signaling and cooperation. *Journal of Theoretical Biology* 213(1):103-119.

Glass, B. P. and M. L. Thies

1997 *A Key to the Skulls of North American Mammals*. B. P. Glass, Stillwater, Okla.

Grayson, D. K.

1988 *Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas*. Anthropological papers of the American Museum of Natural History, v. 66, pt. 1 66. American Museum of Natural History, New York, N.Y.

1989 Bone transport, bone destruction, and reverse utility curves. *Journal of Archaeological Science* 16(6):643-652.

1991 Alpine Faunas from the White Mountains, California - Adaptive Change in the Late Prehistoric Great-Basin. *Journal of Archaeological Science* 18(4):483-506.

2000a The Homestead Cave Mammals. In *Late Quaternary paleoecology in the Bonneville Basin*, edited by D. B. Madsen, pp. 67-89. Utah Geological Survey, Salt Lake City.

2000b Mammalian responses to Middle Holocene climatic change in the Great Basin of the western United States. *Journal of Biogeography* 27(1):181-192.

2002 Great Basin Mammals and Late Quaternary Climate History. In *Great Basin Aquatic Systems History*, edited by R. Hershler, D. B. Madsen and D. R. Currey, pp. 369. Smithsonian Contributions to the Earth Sciences. vol. No. 33. Smithsonian Institution Press, Washington, D.C.

2006 Holocene bison in the Great Basin, western USA. *The Holocene* 16(6):913-925.

Grayson, D. K. and M. Cannon

1999 Human paleoecology and foraging theory in the Great Basin. In *Models for the Millennium: Great Basin Anthropology Today*, edited by C. Beck. University of Utah Press, Salt Lake City.

Grayson, D. K. and J. L. Fisher

2009 Holocene Elk (Cervus elaphus) in the Great Basin. In *Past, Present and Future Issues in Great Basin Archaeology: Papers in Honor of Don D. Fowler*, edited by B. Hockett. U.S. Department of the Interior: Bureau of Land Management, Nevada.

Gurven, M. and C. von Rueden

2006 Hunting, Social Status and Biological Fitness. *Social Biology* 53:81-99.

Grayson, D. K. and C. J. Frey

2004 Measuring skeletal part representation in archaeological faunas. *Journal of Taphonomy* 2(1):27-42.

Grimstead, D. N.

2010 Ethnographic and Modeled Costs of Long-Distance, Big-Game Hunting. *American Antiquity* 75(1):61-80.

Grimstead, D. N. and A. C. Reynolds

2008 Spatial and Temporal Pattens of Resource Intensification from 87Sr/86Sr ratios of Archaeofauna Derived from Chaco Canyon, New Mexico. Paper presented at the Society for American Archaeology, Vancouver, B.C.

Gurven, M.

2004a Reciprocal altruism and food sharing decisions among Hiwi and Ache hunter-gatherers. *Behavioral Ecology and Sociobiology* 56(4):366-380.

2004b To give and to give not: The behavioral ecology of human food transfers. *Behavioral and Brain Sciences* 27(4):543-+.

2006 The evolution of contingent cooperation. *Current Anthropology* 47(1):185-192.

Gurven, M., K. Hill, H. Kaplan, A. Hurtado and R. Lyles

2000 Food transfers among Hiwi foragers of Venezuela: Tests of reciprocity. *Human Ecology* 28(2):171-218.

Hall, E. R.

1946 *Mammals of Nevada*. University of California Press, Berkeley; Los Angeles.

1981 *The mammals of North America*. Wiley, New York.

Hall, R. J., E. J. Milner-Gulland and F. Courchamp

2008 Endangering the endangered: The effects of perceived rarity on species exploitation. *Conservation Letters* 1(2):75-81.

Hames, R. and C. McCabe
2007 Meal sharing among the Ye'kwana. *Human Nature-an Interdisciplinary Biosocial Perspective* 18(1):1-21.

Hames, R. B. and W. T. Vickers
1982 Optimal diet breadth theory as a model to explain variability in Amazonian hunting. *American ethnologist* 9(2):358-378.

Hansen, C.
1980 Habitat. In *The Desert bighorn, its life history, ecology & management*, edited by G. Monson, L. Sumner and R. W. Allen. University of Arizona Press, Tucson.

Hansen, C. and Deming
1980 Growth and Development. In *The Desert bighorn, its life history, ecology & management*, edited by G. Monson, L. Sumner and R. W. Allen. University of Arizona Press, Tucson.

Hawkes, K.
1990 Why do Men Hunt? Benefits for Risky Choices. In *Risk and uncertainty in tribal and peasant economies*, edited by E. A. Cashdan. Westview Press, Boulder.

1992 Sharing and Collective Action. In *Evolutionary Ecology and Human Behavior*, edited by E. A. Smith and B. Winterhalder, pp. 269-300. Aldine de Gruyter, New York.

1993a On Why Male Foragers Hunt and Share Food - Reply. *Current Anthropology* 34(5):706-709.

1993b Why Hunter-Gatherers Work--An ancient version of the problem of Public-Goods. *Current Anthropology* 34(4):341-361.

1996 Foraging differences between men and women: Behavioural ecology of the sexual division of labour. In *The Archaeology of Human Ancestry: Power, Sex and Tradition*, edited by J. Steele and S. Shennan, pp. 283-305. Routledge, London.

Hawkes, K. and R. B. Bird
2002 Showing off, handicap signaling, and the evolution of men's work. *Evolutionary Anthropology* 11(2):58-67.

Hawkes, K. and R. Bliege Bird
2002 Showing off, handicap signaling, and the evolution of men's work. *Evolutionary Anthropology* 11(2):58-67.

Hawkes, K., J. F. O'Connell and N. G. B. Jones

2001a Hadza meat sharing. *Evolution and Human Behavior* 22(2):113-142.

2001b Hunting and nuclear families - Some lessons from the Hadza about men's work. *Current Anthropology* 42(5):681-709.

Haynes, G.
2007 A review of some attacks on the overkill hypothesis, with special, attention to misrepresentations and doubletalk. *Quaternary International* 169:84-94.

Hedman, K. M., B. B. Curry, T. M. Johnson, P. D. Fullagar and T. E. Emerson
2009 Variation in strontium isotope ratios of archaeological fauna in the Midwestern United States: a preliminary study. *Journal of Archaeological Science* 36(1):64-73.

Heffelfinger, J.
2010 *Age criteria for Arizona game species*. Arizona Game and Fish Dept., Phoenix, Ariz.

Henrich, J. and F. J. Gil-White
2001 The evolution of prestige - Freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution and Human Behavior* 22(3):165-196.

Hildebrand, M.
1955 Skeletal differences between deer, sheep and goats. *California Fish and Game*.

Hildebrandt, W. R. and K. R. McGuire
2002 The ascendance of hunting during the California Middle Archaic: An evolutionary perspective. *American Antiquity* 67(2):231-256.

2003 Large-game hunting, gender-differentiated work organization, and the role of evolutionary ecology in California and Great Basin prehistory: A reply to Broughton and Bayham. *American Antiquity* 68(4):790-792.

Hillson, S.
2005 *Teeth*. 2nd ed. Cambridge Manuals in Archaeology. Cambridge University Press, New York.

Hockett, B.
2005 Middle and Late Holocene hunting in the Great Basin: A critical review of the debate and future prospects. *American Antiquity* 70(4):713-731.

Hockett, B. and J. A. Haws

2002 Taphonomic and methodological perspectives of leporid hunting during the Upper Paleolithic of the western Mediterranean basin. *Journal of Archaeological Method and Theory* 9(3):269-302.

Hockett, B. S.
1998 Sociopolitical meaning of faunal remains from Baker Village. *American Antiquity* 63(2):289-302.

Hockett, B. S. and N. Ferreira Bicho
2000 The rabbits of Picareiro Cave: Small mammal hunting during the Late Upper Palaeolithic in the Portuguese Estremadura. *Journal of Archaeological Science* 27(8):715-723.

Hoffmeister, D. F.
1986 *Mammals of Arizona*. University of Arizona Press, Tucson.

Hoppe, K. A.
2004 Late Pleistocene mammoth herd structure, migration patterns, and Clovis hunting strategies inferred from isotopic analyses of multiple death assemblages. *Paleobiology* 30(1):129-145.

Hoppe, K. A., P. L. Koch, R. W. Carlson and S. D. Webb
1999 Tracking mammoths and mastodons: Reconstruction of migratory behavior using strontium isotope ratios. *Geology* 27(5):439-442.

Howard, W. E.
1949 A Means to Distinguish Skulls of Coyotes and Domestic Dogs. *Journal of Mammalogy* 30(2):169-171.

Hudson, J.
1993 The impacts of domestic dogs on bone in forager camps; Or, the dog-gone bones. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Hurlbut, S. A.
2000 The taphonomy of cannibalism: A review of anthropogenic bone modification in the American Southwest. *International Journal Of Osteoarchaeology* 10(1):4-26.

Janetski, J. C.
1994 Recent Transitions in the Eastern Great Basin: The Archaeological Record. In *Across the West : human population movement and the expansion of the Numa*, edited

by D. B. Madsen and D. Rhode, pp. 157-178. University of Utah Press, Salt Lake City.

1997 Fremont hunting and resource intensification in the eastern Great Basin. *Journal of Archaeological Science* 24(12):1075-1088.

1998 *Archaeology of Clear Creek Canyon*. Museum of Peoples and Cultures Popular Series No. 1. Brigham Young University, Provo, Utah.

Janetski, J. C., R. K. Talbot, D. E. Newman, L. D. Richens and J. D. Wilde
2000 *Clear Creek Canyon Archaeological Project: Results and Synthesis*. Museum of Peoples and Cultures Occasional Papers No. 7. Brigham Young University, Provo, Utah.

Jennings, J. D.
1978 *Prehistory of Utah and the Eastern Great Basin*. University of Utah Press, Salt Lake City.

Jochim, M. A.
1988 Optimal Foraging And The Division Of Labor. *American Anthropologist* 90(1):130-136.

Jones, J. K. and R. W. Manning
1992 *Illustrated Key to Skulls of Genera of North American Land Mammals*. Texas Tech University Press, Lubbock, Tex.

Jones, K. T. and D. B. Madsen
1989 Calculating the cost of resource transportation: a Great Basin example. *Current Anthropology* 30(4):529-534.

Kaplan, H., K. Hill, J. Lancaster and A. M. Hurtado
2000 A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology* 9(4):156-185.

Kelly, R. L.
1995 *The foraging spectrum : diversity in hunter-gatherer lifeways*. Smithsonian Institution Press, Washington.

Kent, S.
1981 The Dog: an Archaeologist's Best Fried or Worst Enemy--the Spatial Distribution of Faunal Remains. *Journal Of Field Archaeology* 8(3):367-390.

1993 Variability in faunal assemblages--the influcence of hunting skill, sharing, dogs, and mode of cooking on faunal remains at a sedentary Kalahari community. *Journal of Anthropological Archaeology* 12(4):323-385.

Krausman, P. R., A. V. Sandoval and R. C. Etchberger

1999 Natural history of desert bighorn sheep. In *Mountain sheep of North America*, edited by R. Valdez and P. R. Krausman, pp. 139-191. University of Arizona Press, Tucson.

Kreutzer, L. A.

1992 Bison and deer bone-mineral densities--comparisons and implications for the interpretation of archaeological faunas. *Journal of Archaeological Science* 19(3):271-294.

Lam, Y. M., X. B. Chen, C. W. Marean and C. J. Frey

1998 Bone density and long bone representation in archaeological faunas: Comparing results from CT and photon densitometry. *Journal of Archaeological Science* 25(6):559-570.

Lam, Y. M., X. B. Chen and O. M. Pearson

1999 Intertaxonomic variability in patterns of bone density and the differential representation of bovid, cervid, and equid elements in the archaeological record. *American Antiquity* 64(2):343-362.

Lam, Y. M. and O. M. Pearson

2004 The Fallibility of Bone Density Values and Their Use in Archaeological Analyses. *Journal of Taphonomy* 2(2):99-112.

2005 Bone density studies and the interpretation of the faunal record. *Evolutionary Anthropology* 14(3):99-108.

Lam, Y. M., O. M. Pearson, C. W. Marean and X. B. Chen

2003 Bone density studies in zooarchaeology. *Journal of Archaeological Science* 30(12):1701-1708.

LaMarche, V. C.

1973 Holocene climatic variations inferred from treeline fluctuations in the White Mountains, California. *Quaternary Research* 3(4):632-660.

Larsen, C. S., R. L. Kelly and P. Carson-Stillwater Archaeological

1995 *Bioarchaeology of the Stillwater Marsh: prehistoric human adaptation in the western Great Basin*. American Museum of Natural History, New York, N.Y.

Lawrence, B.

1951 *Mammals found at the Awatovi Site: Post-cranial skeletal characters of deer, pronghorn, and sheep-goat, with notes on bos and bison*. The Peabody Museum, Cambridge, Mass.

Lewall, E. F. and I. M. Cowan

1963 Age Determination in Black-Tail Deer by Degree of Ossification of Epiphyseal Plate in Long Bones. *Canadian Journal of Zoology* 41(4):629-&.

Lindstrom, S.

1990 Submerged tree stumps as indicators of mid-Holocene aridity in the Lake Tahoe Basin. *Journal of California and Great Basin anthropology* 12(2):146-157.

Lohse, E. S.

1980 Fremont Settlement Pattern and Architectural Variation. In *Fremont perspectives*, edited by D. B. Madsen, pp. 41-54. Antiquities Section Selected Papers. vol. Volume VII, Number 16. Utah State Historical Society, Salt Lake City.

Louderback, L. A. and D. E. Rhode

2009 15,000 Years of vegetation change in the Bonneville basin: the Blue Lake pollen record. *Quaternary Science Reviews* 28(3-4):308-326.

Lowie, R. H.

1924 *Notes on Shoshonean ethnography*. American museum press, New York,.

Ludwig, D. R.

1984 Microtus richardsoni. *Mammalian Species* 223:1-6.

Lupo, K. D.

1994 Butchering marks and carcass acquisition strategies: Distinguishing hunting from scavenging in archaeological contexts. *Journal of Archaeological Science* 21(6):827-837.

1995 Hadza bone assemblages and hyena attrition: An ethnographic example of the influence of cooking and mode of discard on the intensity of scavenger ravaging. *Journal of Anthropological Archaeology* 14(3):288-314.

2001 Archaeological skeletal part profiles and differential transport: An ethnoarchaeological example from Hadza bone assemblages. *Journal of Anthropological Archaeology* 20(3):361-378.

2006 What explains the carcass field processing and transport decisions of contemporary hunter-gatherers? Measures of economic anatomy and zooarchaeological skeletal part representation. *Journal of Archaeological Method and Theory* 13(1):19-66.

2007 Evolutionary foraging models in zooarchaeological analysis: Recent applications and future challenges. *Journal of archaeological research* 15(2):143-189.

Lupo, K. D. and D. N. Schmitt

1997a Experiments in bone boiling: Nutritional returns and archaeological]signatures reflections. *Athropozoologica* 25-26:137-144.

1997b On late Holocene variability in bison populations in the northeastern Great Basin. *Journal of California and Great Basin anthropology* 19(1):50-69.

2002 Upper Paleolithic net-hunting, small prey exploitation, and women's work effort: A view from the ethnographic and ethnoarchaeological record of the Congo Basin. *Journal of Archaeological Method and Theory* 9(2):147-179.

2004 Meat Sharing and the archaeological record: A test of the show-off hypothesis among Central African Bofi foragers. In *Hunters and Gatherers in Theory and Archaeology*, edited by G. M. Crothers, pp. 241-260. Occasional Paper No. 31. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Lyman, R. L.

1984 Bone-Density and Differential Survivorship of Fossil Classes. *Journal of Anthropological Archaeology* 3(4):259-299.

1985 Bone Frequencies: Differential transport, in situ destruction, and the Mgui. *Journal of Archaeological Science* 12(3):221-236.

1992 Anatomical Considerations of Utility Curves in Zooarchaeology. *Journal of Archaeological Science* 19(1):7-22.

1994 *Vertebrate Taphonomy*. Cambridge University Press, New York.

2003 Pinniped behavior, foraging theory, and the depression of metapopulations and nondepression of a local population on the southern Northwest Coast of North America. *Journal of Anthropological Archaeology* 22(4):376-388.

2006 Identifying bilateral pairs of deer (Odocoileus sp.) bones: how symmetrical is symmetrical enough? *Journal of Archaeological Science* 33(9):1256-1265.

2008 *Quantitative Paleozoology*. Cambridge manuals in archaeology. Cambridge University Press, Cambridge.

2010 Mandibular hypodontia and osteoarthritis in prehistoric bighorn sheep (*Ovis canadensis*) in eastern Washington State, USA. *International Journal Of Osteoarchaeology* 20(4):396-404.

Lyman, R. L., L. E. Houghton and A. L. Chambers

1992 The effect of structural density on marmot skeletal part representation in archaeological sites. *Journal of Archaeological Science* 19(5):557-573.

Lyon, P. J.

1970 Differential Bone Destruction: An Ethnographic Example. *American Antiquity* 35(2):213-215.

Madrigal, T. C. and S. D. Capaldo

1999 White-tailed deer marrow yields and late archaic hunter-gatherers. *Journal of Archaeological Science* 26(3):241-249.

Madsen, D. B.

1979 New Views on the Fremont: The Fremont and the Sevier: Defining Prehistoric Agriculturalists North of the Anasazi. *American Antiquity* 44(4):711-722.

1980a *Fremont perspectives*. Antiquities Section Selected Papers Volume VII, Number 16. Utah State Historical Society, Salt Lake City.

1980b Fremont/Sevier Subsistence. In *Fremont perspectives*, edited by D. B. Madsen, pp. 25-34. Antiquities Section Selected Papers. vol. Volume VII, Number 16. Utah State Historical Society, Salt Lake City.

1989 *Exploring the Fremont*. Occasional publication (Utah Museum of Natural History) no. 8. Utah Museum of Natural History, Salt Lake City, Utah.

Madsen, D. B. and L. M. W. Lindsay

1977 *Backhoe Village*. Utah State Historical Society. Antiquities Section. Antiquities Section selected papers no. 12. Utah State Historical Society, Salt Lake City.

Madsen, D. B., T. R. Scott and B. Loosle

2000 Differential Transport Costs and High-Altitude Occupation Patterns in the Uinta Mountains, Northeastern Utah. In *Intermountain archaeology*, edited by D. B. Madsen and M. D. Metcalf, pp. 15-24. University of Utah Anthropological Papers. vol. No. 122. University of Utah Press, Salt Lake City.

Madsen, D. B. and S. R. Simms

1998 The Fremont complex: A behavioral perspective (North America, anthropology). *Journal of World Prehistory* 12(3):255-336.

Magurran, A. E.

1988 *Ecological Diversity and its Measurement*. Princeton University Press, Princeton, N.J.

Marean, C. W. and C. J. Frey

1997 Animal bones from caves to cities: Reverse utility curves as methodological artifacts. *American Antiquity* 62(4):698-711.

Marean, C. W. and L. M. Spencer

1991 Impact of carnivore ravaging on zooarchaeological measures of element abundance. *American Antiquity* 56(4):645-658.

Marean, C. W., L. M. Spencer, R. J. Blumenschine and S. D. Capaldo

1992 Captive hyaena bone choice and destruction, the Schlepp effect and Olduvai archaeofaunas. *Journal of Archaeological Science* 19(1):101-121.

Marlowe, F. W.

2003 A critical period for provisioning by Hadza men - Implications for pair bonding. *Evolution and Human Behavior* 24(3):217-229.

2007 Hunting and gathering - The human sexual division of foraging labor. *Cross-Cultural Research* 41(2):170-195.

Marshall, F.

1993 Food sharing and the faunal record. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretations of Faunal Remains*, edited by J. Hudson, pp. 228-246. Occassional Paper No. 21. Southern Illinois University Center for Archaeological Investigations, Carbondale.

1994 Food Sharing and Body Part Representation in Okiek Faunal Assemblages. *Journal of Archaeological Science* 21(1):65-77.

Maser, C. and R. M. Storm

1970 *A Key to Microtinae of the Pacific Northwest (Oregon, Washington, Idaho)*. O.S.U. Book Stores, Corvallis, Ore.

Maynard Smith, J. and D. Harper

2003 *Animal signals*. 1st ed. Oxford series in ecology and evolution. Oxford University Press, New York.

McGuire, K. R., M. G. Delacorte, K. Carpenter and Nevada State Museum.

2004 *Archaeological excavations at Pie Creek and Tule Valley shelters, Elko County, Nevada*. Nevada State Museum, Carson City, Nev.

McGuire, K. R. and W. R. Hildebrandt

2005 Re-Thinking Great Basin Foragers: Prestige Hunting and Costly Signaling During the Middle Archaic Period. *American Antiquity* 70(4).

McGuire, K. R., W. R. Hildebrandt and K. L. Carpenter

2007 Costly signaling and the ascendance of no-can-do archaeology: a reply to Codding and Jones. *American Antiquity* 72(2):358-366.

Metcalfe, D. and K. M. Heath

1990 Microrefuse and site structure--the hearths and floors of Heartbreak Hotel *American Antiquity* 55(4):781-796.

Metcalfe, D. and K. T. Jones

1988 A Reconsideration of Animal Body-Part Utility Indexes. *American Antiquity* 53(3):486-504.

Morin, E.

2007 Fat composition and Nunamiut decision-making: a new look at the marrow and bone grease indices. *Journal of Archaeological Science* 34(1):69-82.

Munro, N. D.

2004 Zooarchaeological measures of hunting pressure and occupation intensity in the Natufian - Implications for agricultural origins. *Current Anthropology* 45:S5-S33.

Munson, P. J. and R. C. Garniewicz

2003 Age-mediated survivorship of ungulate mandibles and teeth in canid-ravaged faunal assemblages. *Journal of Archaeological Science* 30(4):405-416.

Nagaoka, L.

2001 Using diversity indices to measure changes in prey choice at the Shag River Mouth Site, southern New Zealand. *International Journal Of Osteoarchaeology* 11(1):101-111.

2002a The effects of resource depression on foraging efficiency, diet breadth, and patch use in southern New Zealand. *Journal of Anthropological Archaeology* 21(4):419-442.

2002b Explaining subsistence change in southern New Zealand using foraging theory models. *World Archaeology* 34(1):84-102.

2005 Declining foraging efficiency and moa carcass exploitation in southern New Zealand. *Journal of Archaeological Science* 32(9):1328-1338.

Negrini, R. M.
2002 Pluvial Lake Sizes in the Northwestern Great Basin throughout the Quaternary Period. In *Great Basin Aquatic Systems History*, edited by R. Hershler, D. B. Madsen and D. R. Currey, pp. 11-52. Smithsonian Contributions to the Earth Sciences. vol. No. 33. Smithsonian Institution Press, Washington, D.C.

Neiman, F. D.
1997 Conspicuous consumption as wasteful advertising: a Darwinian perspective on spatial patterns in Classic Maya terminal monument dates. In *Rediscovering Darwin: evolutionary theory and archeological explanation*, edited by C. M. Barton, G. A. Clark and D. B. Bamforth. Archeological papers of the American Anthropological Association; no. 7. American Anthropological Association, Arlington, Va.

Newman, D. E.
2000 Paleoenvironment. In *Clear Creek Canyon Archaeological Project: Results and Synthesis.*, edited by J. C. Janetski, R. K. Talbot, D. E. Newman, L. D. Richens and J. D. Wilde, pp. 241-246. Museum of Peoples and Cultures Occasional Papers. vol. No. 7. Brigham Young University, Provo, Utah.

Nowak, R. M. and E. P. Walker
1991 *Walker's mammals of the world*. 5th ed. Johns Hopkins University Press, Baltimore.

O'Connell, J. F., K. Hawkes and N. B. Jones
1990 Reanalysis of large mammal body part transport among the Hadza. *Journal of Archaeological Science* 17(3):301-316.

O'Gara, B. W.
1978 Antilocapra americana. *Mammalian Species* (90):1-7.

2004 Physical characteristics. In *Pronghorn: Ecology and Management*, edited by B. W. O'Gara and J. D. Yoakum. University Press of Colorado, Boulder, Colo.

Oaks, E. C., P. J. Young, Gordon L. Kirkland, Jr. and D. F. Schmidt
1987 Spermophilus variegatus. *Mammalian Species* (272):1-8.

Olsen, S. L. and P. Shipman
1988 Surface modification on bone: Trampling versus butchery. *Journal of Archaeological Science* 15(5):535-553.

Outram, A. K.
2001 A New Approach to Identifying Bone Marrow and Grease Exploitation: Why the "Indeterminate" Fragments should not be Ignored. *Journal of Archaeological Science* 28(4):401-410.

2004 Identifying dietary stress in marginal environments: Bone fats, optimal foraging theory and the seasonal round. In *Colonisation, Migration and Marginal Areas: A Zooarchaeological Approach*, edited by M. Mondini, S. Muñoz and S. Wickler, pp. 74-85. Oxbow, Oxford.

Panter-Brick, C.
2002 Sexual division of labor: Energetic and evolutionary scenarios. *American Journal of Human Biology* 14(5):627-640.

Parmalee, P. W. and W. E. Klippel
1983 The Role of Native Animals in the food Economy of the Historic Kickapoo in central Illinois. In *Lulu linear punctated : essays in honor of George Irving Quimby*, edited by R. C. D. Dunnell and D. K. Grayson, pp. 253-324. Anthropological Papers No. 72. Museum of Anthropology, University of Michigan, Ann Arbor.

Patton, J. Q.
2005 Meat sharing for coalitional support. *Evolution and Human Behavior* 26(2):137-157.

Pavao, B. and P. W. Stahl
1999 Structural density assays of Leporid skeletal elements with implications for taphonomic, actualistic and archaeological research. *Journal of Archaeological Science* 26(1):53-66.

Phoca-Cosmetatou, N.
2005 Bone weathering and food procurement strategies : assessing the reliability of our behavioural inferences. In *Biosphere to lithosphere : new studies in vertebrate taphonomy*, edited by T. P. O'Connor. Oxbow Books, Oxford.

Pickering, T. R. and C. P. Egeland
2006 Experimental patterns of hammerstone percussion damage on bones: implications for inferences of carcass processing by humans. *Journal of Archaeological Science* 33(4):459-469.

Plourde, A. M.
2008 The origins of prestige goods as honest signals of skill and knowledge. *Human Nature-an Interdisciplinary Biosocial Perspective* 19(4):374-388.

2009 Prestige Goods and the Formation of Political Hierarchy--A Costly Signaling Model. In *Pattern and Process in Cultural Evolution*. University of California Press.

Potter, J. M. and S. G. Ortman

2002 Community and cuisine in the prehispanic American Southwest. In *Identity, feasting, and the archaeology of the greater Southwest*, edited by B. J. Mills. University Press of Colorado, Boulder, Colo.

Quirt-Booth, T. and K. Cruz-Uribe
1997 Analysis of leporid remains from prehistoric Sinagua sites, northern Arizona. *Journal of Archaeological Science* 24(10):945-960.

Reitz, E. J. and E. S. Wing
2008 *Zooarchaeology*. 2nd ed. Cambridge manuals in archaeology. Cambridge University Press, Cambridge ; New York.

Rhode, D.
2000 Holocene vegetation history in the Bonneville Basin. In *Late Quaternary paleoecology in the Bonneville Basin*, edited by D. B. Madsen, pp. 149-163. Utah Geological Survey, Salt Lake City.

Robinette, W. L., D. A. Jones, G. Rogers and J. S. Gashwiler
1957 Notes on Tooth Development and Wear for Rocky Mountain Mule Deer. *The Journal of Wildlife Management* 21(2):134-153.

Schmitt, D. N., D. B. Madsen and K. D. Lupo
2004 The Worst of Times, the Best of Times: Jackrabbit Hunting by Middle Holocene Human Foragers in the Bonneville Basin of Western North America. In *Colonisation, Migration, and Marginal Areas*, edited by M. Mondini, S. Munoz and S. Wickler, pp. 86-95. Oxbow Books, Oxford.

Shackleton, D. M.
1985 Ovis canadensis. *Mammalian Species* (230):1-9.

Shackleton, D. M., C. C. Shank and B. M. Wikeem
1999 Natural history of Rocky Mountain and California bighorn sheep. In *Mountain sheep of North America*, edited by R. Valdez and P. R. Krausman, pp. 23-77. University of Arizona Press, Tucson.

Shaffer, B. S.
1992 Quarter-inch screening: understanding biases in recovery of vertebrate faunal remains. *American Antiquity* 67(1):129-136.

Shaffer, B. S. and J. L. J. Sanchez
1994 Comparison of 1/8-inch-mesh and 1/4-inch-mesh recovery of controlled samples of small-to-medium-sized mammals. *American Antiquity* 59(3):525-530.

Shannon, J. M., D. D. Olson, S. L. Petersen, J. C. Whiting and J. T. Flinders

2008 Can GIS Models Predict Habitat Use of Reintroduced Bighorn Sheep? *Proceedings of the 2008 ESRI User Conference*.

Sharp, N. D.
1992 Fremont Farmers and Hunters: faunal resource exploitation at Nawthis Village, Central Utah.

Shott, M. J.
1993 Spears, Darts, and Arrows - Late Woodland Hunting Techniques in the Upper Ohio Valley. *American Antiquity* 58(3):425-443.

Simmons, N.
1980 Behavior. In *The Desert bighorn, its life history, ecology & management*, edited by G. Monson, L. Sumner and R. W. Allen. University of Arizona Press, Tucson.

Smith, E. A.
2004 Why do good hunters have higher reproductive success? *Human Nature-an Interdisciplinary Biosocial Perspective* 15(4):343.

Smith, E. A., R. B. Bliege Bird and D. W. Bird
2003 The benefits of costly signaling: Meriam turtle hunters. *Behavioral Ecology* 14(1):116-126.

Smith, E. A. and B. P. Winterhalder (editors)
1992 *Evolutionary ecology and human behavior*. Aldine de Gruyter, New York.

Smith, F. A.
1997 Neotoma cinerea. *Mammalian Species* (564):1-8.

Spence, M.
1973 Job Market Signaling. *The Quarterly Journal of Economics* 87(3):355-374.

Speth, J. D.
2000 Boiling vs. baking and roasting: a taphonomic approach to the recognition of cooking techniques in small mammals. In *Animal bones, human societies*, edited by P. Rowley-Conwy. Oxbow Books, Oakville, CT.

Speth, J. D. and S. L. Scott
1989 Horticulture and large-mammal hunting: the role of resource depletion and the costraints of time and labor. In *Farmers as hunters : the implications of sedentism*, edited by S. Kent, pp. 71-79. Cambridge University Press, Cambridge [Cambridgeshire] ; New York.

Speth, J. D. and K. A. Spielmann
1983 Energy-Source, Protein-Metabolism, and Hunter Gatherer Subsistence Strategies. *Journal of Anthropological Archaeology* 2(1):1-31.

Stahl, P. W.
1999 Structural density of domesticated South American camelid skeletal elements and the archaeological investigation of prehistoric Andean charki. *Journal of Archaeological Science* 26(11):1347-1368.

Stephens, D. W. and J. R. Krebs
1986 *Foraging theory*. Monographs in behavior and ecology. Princeton University Press, Princeton, N.J.

Steward, J. H.
1933 *Ethnography of the Owens valley Paiute*. University of California Press, Berkeley,.

1938 *Basin-plateau aboriginal sociopolitical groups*. U.S. Govt. Print. Off., Washington.

Stiner, M. C.
2002 On in-situ attrition and vertebrate body part profiles. *Journal of Archaeological Science* 29(9):979-991.

Stiner, M. C., S. L. Kuhn, S. Weiner and O. Baryosef
1995 Differential Burning, Recrystallization, and Fragmentation of Archaeological Bone. *Journal of Archaeological Science* 22(2):223-237.

Symmons, R.
2005 Bone density variation between similar animals and density variation in early life: Implications for future taphonomic analysis. In *Biosphere to Lithosphere: New Studies in Vertebrate Taphonomy*, edited by T. P. O'Connor. Oxbow Books, Oxford.

Szuter, C. R.
1991 *Hunting by prehistoric horticulturists in the American Southwest*. Garland, New York.

Szuter, C. R. and F. E. Bayham
1989 Sedentism and prehistoric animal procurement among desert horticulturalists of the North American Southwest. In *Farmers as hunters : the implications of sedentism*, edited by S. Kent, pp. 80-95. Cambridge University Press, Cambridge.

Talbot, R. K.

2000 Fremont Farmers: The Search for Context. In *The archaeology of regional interaction: religion, warfare, and exchange across the American Southwest and beyond*, edited by M. Hegmon, pp. 235-256. University Press of Colorado, Boulder.

Talbot, R. K. and J. C. Janetski

2000 Use of Space at Five Finger Ridge. In *Clear Creek Canyon Archaeological Project: Results and Synthesis*, edited by J. C. Janetski, R. K. Talbot, D. E. Newman, L. D. Richens and J. D. Wilde. Museum of Peoples and Cultures Occasional Papers. vol. No. 7. Brigham Young University, Provo, Utah.

Talbot, R. K., L. D. Richens, J. D. Wilde, J. C. Janetski and D. E. Newman

1998 *Archaeological surveys and limited excavations, Clear Creek Canyon, central Utah*. Museum of Peoples and Cultures Occasional Papers No. 3. Brigham Young University, Provo, Utah.

Talbot, R. K., L. D. Richens, J. D. W. Wilde, J. C. Janetski and D. E. Newman

2000 *Excavations at Five Finger Ridge, Clear Creek Canyon, Central Utah*. Museum of Peoples and Cultures Occasional Papers No. 5. Brigham Young University, Provo, Utah.

Talbot, R. K. and J. D. Wilde

1989 Giving form to the Formative: shifting settlement patterns in the eastern Great Basin and northern Colorado Plateau. *Utah Archaeology* 2(1):3-18.

Thaeler, C. S.

1980 Chromosome-Numbers and Systematic Relations in the Genus *Thomomys* (Rodentia, Geomyidae). *Journal of Mammalogy* 61(3):414-422.

Thomas, D. H.

1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34(4):392-401.

Thompson, R. S.

1992 Late Quaternary environments in Ruby Valley, Nevada. *Quaternary Research* 37(1):1.

Trivers, R. L.

1971 Evolution of Reciprocal Altruism. *Quarterly Review of Biology* 46(1):35-&.

Turner, C. G. and J. A. Turner

1999 *Man Corn: Cannibalism and Violence in the Prehistoric American Southwest*. University of Utah Press, Salt Lake City.

Turner, J. C. and C. Hansen

1980 Reproduction. In *The Desert bighorn, its life history, ecology & management*, edited by G. Monson, L. Sumner and R. W. Allen. University of Arizona Press, Tucson.

Ugan, A.

2005a Climate, bone density, and resource depression: What is driving variation in large and small game in Fremont archaeofaunas? *Journal of Anthropological Archaeology* 24(3):227-251.

2005b Does size matter? Body size, mass collecting, and their implications for understanding prehistoric foraging behavior. *American Antiquity* 70(1):75-89.

2010 The effect of cooking on the survivorship of jackrabbit skeletons (*Lepus californicus*) presented to desert scavengers of the eastern Great Basin, North America. *International Journal Of Osteoarchaeology* 20(2):214-226.

Valdez, R. and P. R. Krausman

1999 Description, distribution, and abundance of mountain sheep in North America. In *Mountain sheep of North America*, edited by R. Valdez and P. R. Krausman, pp. 3-22. University of Arizona Press, Tucson.

Valentine, B., G. D. Kamenov and J. Krigbaum

2008 Reconstructing Neolithic groups in Sarawak, Malaysia through lead and strontium isotope analysis. *Journal of Archaeological Science* 35(6):1463-1473.

Veblen, T.

1994 (1899) *The theory of the leisure class*. Penguin twentieth-century classics. Penguin Books, New York, N.Y., U.S.A.

Verts, B. J. and L. N. Carraway

2002 Neotoma lepida. *Mammalian Species* (699):1-12.

Verts, B. J., L. N. Carraway and A. Kinlaw

2001 Spilogale gracilis. *Mammalian Species* 674:1-10.

Verts, B. J. and G. L. J. Kirkland

1988 Perognathus parvus. *Mammalian Species* 318:1-8.

Waguespack, N. M.

2002 Caribou sharing and storage: refitting the Palangana site. *Journal of Anthropological Archaeology* 21(3):396-417.

Walker, D. N.

1987 Sequence of Epiphyseal Fusion in the Rocky-Mountain Bighorn Sheep. *Great Basin Naturalist* 47(1):7-12.

Wandsnider, L.
1997 The roasted and the boiled: Food composition and heat treatment with special emphasis on pit-hearth cooking. *Journal of Anthropological Archaeology* 16(1):1-48.

Weinreb, M. M. and Y. Sharav
1964 Tooth Development in Sheep. *American Journal of Veterinary Research* 25(107):891-&.

White, T. D.
1992 *Prehistoric Cannibalism at Mancos 5MTUMR-2346*. Princeton University Press, Princeton, N.J.

Whiting, J. C., J. T. Flinders and G. L. Ogborn
2004 GIS Winter and Lambing Range Habitat Models for Reintroducing Bighorn Sheep in North Central Utah. *Proceedings of the 2004 ESRI User Conference*.

Wiessner, P.
2002 Hunting, healing, and hxaro exchange - A long-term perspective on !Kung (Ju/'hoansi) large-game hunting. *Evolution and Human Behavior* 23(6):407-436.

Wigand, P. E. and D. Rhode
2002 Great Basin Vegetation History and Aquatic Systems: The Last 150,000 Years. In *Great Basin Aquatic Systems History*, edited by R. Hershler, D. B. Madsen and D. R. Currey, pp. 309. Smithsonian Contributions to the Earth Sciences. vol. No. 33. Smithsonian Institution Press, Washington, D.C.

Winterhalder, B.
1986 Diet choice, risk, and food sharing in a stochastic environment. *Journal of Anthropological Archaeology* 5(4):369-392.

1996 A marginal model of tolerated theft. *Ethology and Sociobiology* 17(1):37-53.

Winterhalder, B. and D. J. Kennett
2006 Behavioral Ecology and the Transition from Hunting and Gathering to Agriculture. In *Behavioral ecology and the transition to agriculture*, edited by D. J. Kennett and B. Winterhalder, pp. 1-21. University of California Press, Berkeley.

Winterhalder, B. and F. Lu
1997 A forager resource population ecology model and implications for indigenous conservation. *Conservation Biology* 11(6):1354-1364.

Yellen, J. E.

1977 Cultural Patterning in Faunal Remains: Evidence from the !Kung Bushmen. In *Experimental archeology*, edited by D. Ingersoll, J. E. Yellen and W. Macdonald, pp. 271-331. Columbia University Press, New York.

Yoakum, J. D.

2004 Distribution and Abundance. In *Pronghorn: Ecology and Management*, edited by B. W. O'Gara and J. D. Yoakum. University Press of Colorado, Boulder, Colo.

Zazzo, A., M. Balasse and W. P. Patterson

2006 The reconstruction of mammal individual history: refining high-resolution isotope record in bovine tooth dentine. *Journal of Archaeological Science* 33(8):1177-1187.

Zazzo, A., M. Balasse, W. P. Patterson and P. Patterson

2005 High-resolution delta C-13 intratooth profiles in bovine enamel: Implications for mineralization pattern and isotopic attenuation. *Geochimica Et Cosmochimica Acta* 69(14):3631-3642.

Zeanah, D. W.

2000 Transport Costs, Central-Place Foraging, and Hunter-Gatherer Alpine Land-Use Strategies. In *Intermountain archaeology*, edited by D. B. Madsen and M. D. Metcalf. University of Utah Anthropological Papers. vol. No. 122. University of Utah Press, Salt Lake City.

Zahavi, A.

1975 Mate selection--A selection for a handicap. *Journal of Theoretical Biology* 53(1): 205-214.

Zehavi, A. and A. Zahavi

1997 *The handicap principle: a missing piece of Darwin's puzzle*. Oxford University Press, New York.

Appendix A

TAXONOMIC COUNTS PER PROVENIENCE

The following tables depict the number of identified specimens (NISP) for each taxa. Only structures and activity areas with specimens identified to taxonomic order or finer are included. Provenience data provided by R. Talbot and categorized into “Fill”, “Floor” and “Subfloor”. This requires recategorizing of some proveniences. Floor features, such as hearths, are included under “Floor”, and all fill (including “Floor Zone” and similar categories) are included under a single category of “Fill”. Worked bone specimens have been removed. Raw data used to construct the table is included on the enclosed CD-ROM.

It should be noted that neonatal artiodactyl specimens are separated since they may be treated as a separate resource from adult individuals due to differences in hunting strategy.

The counts for the present analysis and the previous analysis conducted by staff at the Office of Public Archaeology at Brigham Young University do not always match. See Chapter X for details regarding how and why counts differ between the two analyses.

Storage Structure 1				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	-	-	**1**
Sylvilagus sp.	4	1	-	**5**
Thomomys sp.	1	-	-	**1**
Thomomys bottae	-	1	-	**1**
Spermophilus variegatus	1	-	-	**1**
Artiodactyla	3	1	-	**4**
Total	**10**	**3**	**-**	**13**

Pithouse 2				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	3	-	**4**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	96	27	-	**123**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	2	4	-	**6**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	2	-	-	**2**
Thomomys sp.	3	-	-	**3**
Thomomys bottae	2	-	-	**2**
Artiodactyla	9	1	-	**10**
Artiodactyl, Neonatal	3	3	-	**6**
Odocoileus hemionus	2	1	-	**3**
Odocoileus, Neonatal	3	-	-	**3**
Ovis canadensis	4	-	-	**4**
Total	**132**	**39**	**0**	**171**

Pithouse 3				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	24	5	1	**30**
Lepus sp.	55	3	8	**66**
Sylvilagus sp.	531	99	36	**666**
Sylvilagus audubonii	6	-	-	**6**
Sylvilagus nuttallii	11	4	4	**19**
Rodentia	9	2	-	**11**
Sciuridae	2	-	-	**2**
Tamias sp.	1	-	-	**1**
Spermophilus variegatus	13	1	-	**14**
Castor canadensis	1	-	-	**1**
Neotoma lepida	2	-	-	**2**
Ondatra zibethicus	5	-	-	**5**
Erethizon dorsatum	-	1	-	**1**
Thomomys sp.	5	-	-	**5**
Thomomys bottae	9	1	-	**10**
Carnivora	1	1	-	**2**
Artiodactyla	84	6	2	**92**
Artiodactyl, Neonatal	6	1	-	**7**
Odocoileus hemionus	28	6	1	**35**
Antilocapra americana	-	3	-	**3**
Bison bison	1	-	-	**1**
Ovis canadensis	43	10	-	**53**
Total	**837**	**143**	**52**	**1032**

Storage Structure 4				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	14	-	-	**14**
Sylvilagus sp.	65	3	-	**68**
Sylvilagus audubonii	1	-	-	**1**
Sylvilagus nuttallii	1	-	-	**1**
Rodentia	47	-	-	**47**
Tamias sp.	1	-	-	**1**
Thomomys sp.	23	-	-	**23**
Thomomys bottae	7	1	-	**8**
Peromyscus sp.	3	-	-	**3**
Neotoma sp.	4	-	-	**4**
Neotoma cinerea	5	-	-	**5**
Neotoma lepida	8	-	-	**8**
Microtus sp.	8	-	-	**8**
Ondatra zibethicus	1	-	-	**1**
Castor canadensis	11	3	-	**14**
Spilogale gracilis	1	-	-	**1**
Artiodactyla	11	-	-	**11**
Odocoileus hemionus	7	-	-	**7**
Bison bison	5	-	-	**5**
Ovis canadensis	6	-	-	**6**
Total	**230**	**7**	**-**	**237**

Pithouse 5				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	16	4	-	**20**
Sylvilagus audubonii	1	-	-	**1**
Thomomys sp.	2	-	-	**2**
Thomomys bottae	2	-	-	**2**
Artiodactyla	6	1	-	**7**
Artiodactyl, Neonatal	1	-	-	**1**
Antilocapra americana	-	1	-	**1**
Ovis canadensis	1	2	-	**3**
Total	**29**	**8**	**-**	**37**

Storage Structure 6				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Bison bison	2	-	-	**2**
Total	**4**	**-**	**-**	**4**

Pithouse 7				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	21	5	-	**26**
Sylvilagus audubonii	3	-	-	**3**
Sylvilagus nuttallii	1	-	-	**1**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	2	1	-	**3**
Thomomys bottae	1	-	-	**1**
Artiodactyla	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Total	**31**	**6**	**-**	**37**

Storage Structure 8				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	4	-	-	**4**
Odocoileus hemionus	1	-	-	**1**
Total	**5**	**-**	**-**	**5**

Pithouse 9				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	-	-	1	**1**
Lepus sp.	3	1	1	**5**
Sylvilagus sp.	29	10	6	**45**
Rodentia	-	1	2	**3**
Thomomys sp.	1	-	-	**1**
Thomomys bottae	1	-	-	**1**
Castor canadensis	1	-	-	**1**
Artiodactyla	15	1	-	**16**
Odocoileus hemionus	5	-	1	**6**
Ovis canadensis	9	5	-	**14**
Total	**64**	**18**	**11**	**93**

Secondary Pit Structure 10				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	-	-	**1**
Total	**1**	**-**	**-**	**1**

Pithouse 11				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	-	1	-	**1**
Sylvilagus sp.	5	10	-	**15**
Neotoma lepida	-	1	-	**1**
Artiodactyla	1	-	-	**1**
Total	**6**	**12**	**-**	**18**

Pithouse 13				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	6	4	1	**11**
Sylvilagus audubonii	-	2	-	**2**
Rodentia	-	1	-	**1**
Thomomys sp.	-	-	1	**1**
Neotoma sp.	-	1	-	**1**
Neotoma lepida	-	1	-	**1**
Artiodactyla	4	6	1	**11**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	1	1	-	**2**
Ovis canadensis	1	10	-	**11**
Total	**13**	**26**	**3**	**42**

Pithouse 14

Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	7	5	-	**12**
Sylvilagus sp.	16	16	1	**33**
Rodentia	-	2	-	**2**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	1	9	-	**10**
Thomomys bottae	3	-	-	**3**
Peromyscus sp.	-	2	-	**2**
Microtus montanus	1	-	-	**1**
Mustela frenata	-	2	-	**2**
Artiodactyla	18	2	1	**21**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	6	1	-	**7**
Odocoileus, Neonatal	-	4	-	**4**
Ovis canadensis	6	-	-	**6**
Total	**61**	**43**	**2**	**106**

Pithouse 15

Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	4	-	-	**4**
Artiodactyla	1	-	-	**1**
Ovis canadensis	1	-	-	**1**
Total	**6**	**0**	**0**	**6**

Secondary Pit Structure 16

Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	1	-	-	**1**
Sylvilagus sp.	1	-	-	**1**
Rodentia	1	-	-	**1**
Artiodactyla	2	-	-	**2**
Odocoileus hemionus	-	1	-	**1**
Ovis canadensis	-	1	-	**1**
Total	**6**	**2**	**0**	**8**

Pithouse 17

Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	15	5	-	**20**
Sylvilagus sp.	115	15	-	**130**
Sylvilagus audubonii	3	-	-	**3**
Sylvilagus nuttallii	3	-	-	**3**
Rodentia	2	1	-	**3**
Spermophilus sp.	1	-	-	**1**
Spermophilus variegatus	2	-	-	**2**
Thomomys sp.	2	4	-	**6**
Thomomys bottae	13	4	-	**17**
Neotoma sp.	-	1	-	**1**
Neotoma cinerea	2	1	-	**3**
Neotoma lepida	5	1	-	**6**
Microtus sp.	1	-	-	**1**
Microtus longicaudus	2	-	-	**2**
Ondatra zibethicus	1	-	-	**1**
Artiodactyla	26	10	-	**36**
Artiodactyl, Neonatal	6	1	-	**7**
Odocoileus hemionus	1	4	-	**5**
Odocoileus, Neonatal	1	-	-	**1**
Bison bison	-	1	-	**1**
Ovis canadensis	10	9	-	**19**
Total	**211**	**57**	**-**	**268**

Secondary Pit Structure 19

Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	2
Sylvilagus sp.	21	-	-	21
Sciuridae	1	-	-	1
Thomomys bottae	1	-	-	1
Artiodactyla	1	-	-	1
Ovis canadensis	2	-	-	2
Total	**28**	**0**	**0**	**28**

Pithouse 20				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	1	1	**3**
Lepus sp.	11	1	4	**16**
Sylvilagus sp.	85	17	18	**120**
Sylvilagus audubonii	-	-	1	**1**
Sylvilagus nuttallii	-	1	-	**1**
Rodentia	2	-	2	**4**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	4	-	-	**4**
Thomomys sp.	3	-	-	**3**
Thomomys bottae	10	2	-	**12**
Ondatra zibethicus	2	-	-	**2**
Artiodactyla	24	3	-	**27**
Odocoileus hemionus	4	3	2	**9**
Ovis canadensis	3	1	1	**5**
Total	**150**	**29**	**29**	**208**

Secondary Pit Structure 21				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Chiroptera	-	-	1	**1**
Leporidae	3	-	-	**3**
Lepus sp.	40	1	9	**50**
Sylvilagus sp.	62	-	11	**73**
Sciuridae	1	-	-	**1**
Marmota flaviventris	8	-	1	**9**
Spermophilus variegatus	4	-	-	**4**
Thomomys sp.	4	1	3	**8**
Thomomys bottae	9	2	2	**13**
Microtus sp.	2	-	-	**2**
Castor canadensis	1	-	-	**1**
Artiodactyla	42	1	1	**44**
Artiodactyl, Neonatal	2	-	-	**2**
Odocoileus hemionus	12	2	1	**15**
Ovis canadensis	15	2	-	**17**
Total	**205**	**9**	**29**	**243**

Pithouse 22				
Taxon	**Fill**	**Floor**	**Subfloor feature**	**Total**
Leporidae	14	2	-	**16**
Lepus sp.	79	25	11	**115**
Sylvilagus sp.	313	47	50	**410**
Sylvilagus audubonii	7	3	2	**12**
Sylvilagus nuttallii	3	-	-	**3**
Rodentia	4	-	-	**4**
Sciuridae	-	1	-	**1**
Marmota flaviventris	1	-	-	**1**
Spermophilus variegatus	3	1	1	**5**
Thomomys sp.	10	1	-	**11**
Thomomys bottae	15	1	1	**17**
Ondatra zibethicus	1	1	-	**2**
Canis sp.	2	-	-	**2**
Artiodactyla	73	8	4	**85**
Artiodactyl, Neonatal	2	1	-	**3**
Odocoileus hemionus	13	2	-	**15**
Odocoileus, Neonatal	2	-	-	**2**
Bison bison	1	-	-	**1**
Ovis canadensis	26	16	-	**42**
Total	**569**	**109**	**69**	**747**

Storage Structure 23				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	1	1	-	**2**
Rodentia	21	-	-	**21**
Sciuridae	13	-	-	**13**
Ammospermophilus leucurus	3	-	-	**3**
Spermophilus variegatus	7	-	-	**7**
Thomomys sp.	4	-	-	**4**
Thomomys bottae	1	-	-	**1**
Dipodomys sp.	1	-	-	**1**
Peromyscus sp.	4	-	-	**4**
Neotoma sp.	2	-	-	**2**
Neotoma cinerea	2	-	-	**2**
Neotoma lepida	1	-	-	**1**
Microtus sp.	3	-	-	**3**
Ondatra zibethicus	1	-	-	**1**
Artiodactyla	2	-	-	**2**
Odocoileus hemionus	6	-	-	**6**
Antilocapra americana	1	-	-	**1**
Bison bison	2	-	-	**2**
Ovis canadensis	3	-	-	**3**
Total	**80**	**1**	**0**	**81**

Central Structure 24				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	2	-	**3**
Lepus sp.	3	9	-	**12**
Sylvilagus sp.	39	23	-	**62**
Sylvilagus audubonii	1	-	-	**1**
Rodentia	-	3	-	**3**
Sciuridae	-	1	-	**1**
Spermophilus variegatus	1	4	-	**5**
Thomomys sp.	-	1	-	**1**
Thomomys bottae	1	1	-	**2**
Artiodactyla	9	6	-	**15**
Odocoileus hemionus	3	2	-	**5**
Ovis canadensis	4	1	-	**5**
Total	**62**	**53**	**0**	**115**

Surface Structure 25				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	5	-	-	**5**
Sylvilagus sp.	50	7	12	**69**
Sylvilagus audubonii	1	-	-	**1**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	2	2	-	**4**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	1	1	-	**2**
Peromyscus sp.	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Thomomys bottae	2	-	1	**3**
Ondatra zibethicus	1	-	-	**1**
Artiodactyla	2	-	-	**2**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	3	-	-	**3**
Total	**75**	**10**	**13**	**98**

Pithouse 26				
Taxon	**Fill**	**Floor**	**Subfloor feature**	**Total**
Chiroptera	1	0	-	**1**
Leporidae	6	0	1	**7**
Lepus sp.	89	8	-	**97**
Sylvilagus sp.	332	40	9	**381**
Sylvilagus audubonii	2	0	-	**2**
Sylvilagus nuttallii	6	0	2	**8**
Rodentia	12	0	-	**12**
Sciuridae	1	0	-	**1**
Spermophilus variegatus	14	1	-	**15**
Thomomys sp.	22	3	1	**26**
Thomomys bottae	20	5	-	**25**
Microtus sp.	2	0	-	**2**
Ondatra zibethicus	3	0	-	**3**
Carnivora	1	0	-	**1**
Canis sp.	1	1	-	**2**
Mustela frenata	0	0	2	**2**
Artiodactyla	57	3	-	**60**
Artiodactyl, Neonatal	9	1	-	**10**
Odocoileus hemionus	19	2	-	**21**
Bison bison	1	0	-	**1**
Ovis canadensis	36	0	-	**36**
Total	**634**	**64**	**15**	**713**

Storage Structure 27				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	12	-	-	**12**
Thomomys sp.	5	-	-	**5**
Artiodactyla	10	-	-	**10**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	8	-	-	**8**
Total	**38**	**0**	**0**	**38**

Pithouse 28				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	3	5	-	**8**
Lepus sp.	36	18	1	**55**
Sylvilagus sp.	199	137	-	**336**
Sylvilagus audubonii	3	1	-	**4**
Sylvilagus nuttallii	2	1	-	**3**
Rodentia	-	9	-	**9**
Neotoma cinerea	1	-	-	**1**
Neotoma lepida	-	1	-	**1**
Sciuridae	5	-	-	**5**
Spermophilus variegatus	3	2	-	**5**
Thomomys bottae	7	6	-	**13**
Thomomys sp.	8	8	-	**16**
Ondatra zibethicus	1	1	-	**2**
Erethizon dorsatum	1	-	-	**1**
Carnivora	1	2	-	**3**
Canis sp.	3	-	-	**3**
Ursus americanus	1	-	-	**1**
Lynx rufus	1	-	-	**1**
Artiodactyla	93	16	-	**109**
Artiodactyl, Neonatal	13	21	-	**34**
Odocoileus hemionus	29	5	-	**34**
Antilocapra americana	2	1	-	**3**
Ovis canadensis	51	6	-	**57**
Total	**463**	**240**	**1**	**704**

Pithouse 29				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	7	5	-	**12**
Lepus sp.	38	31	2	**71**
Sylvilagus sp.	153	79	4	**236**
Sylvilagus audubonii	1	3	-	**4**
Sylvilagus nuttallii	-	1	-	**1**
Rodentia	2	2	-	**4**
Sciuridae	2	1	-	**3**
Spermophilus variegatus	4	3	-	**7**
Thomomys sp.	1	1	-	**2**
Thomomys bottae	7	2	-	**9**
Ondatra zibethicus	-	1	-	**1**
Carnivora	-	2	-	**2**
Mustela frenata	1	-	-	**1**
Artiodactyla	53	21	1	**75**
Artiodactyl, Neonatal	21	2	-	**23**
Odocoileus hemionus	13	7	-	**20**
Odocoileus, Neonatal	1	2	-	**3**
Ovis canadensis	30	14	-	**44**
Ovis, Neonatal	1	-	-	**1**
Total	**335**	**177**	**7**	**519**

Pithouse 30				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	-	-	**2**
Lepus sp.	24	16	1	**41**
Sylvilagus sp.	119	66	6	**191**
Sylvilagus audubonii	1	1	-	**2**
Sylvilagus nuttallii	2	2	-	**4**
Rodentia	4	-	-	**4**
Sciuridae	5	-	-	**5**
Spermophilus variegatus	-	1	-	**1**
Thomomys bottae	8	9	1	**18**
Thomomys sp.	5	3	2	**10**
Neotoma lepida	1	-	-	**1**
Ondatra zibethicus	1	1	-	**2**
Erethizon dorsatum	2	-	-	**2**
Ursus americanus	1	-	-	**1**
Artiodactyla	52	22	-	**74**
Artiodactyl, Neonatal	3	1	-	**4**
Odocoileus hemionus	18	15	-	**33**
Odocoileus, Neonatal	1	1	-	**2**
Antilocapra americana	3	2	-	**5**
Ovis canadensis	24	7	-	**31**
Total	**276**	**147**	**10**	**433**

Storage Structure 31				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	7	-	-	**7**
Sciuridae	1	-	-	**1**
Spermophilus sp.	1	-	-	**1**
Spermophilus variegatus	2	-	-	**2**
Thomomys bottae	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Neotoma cinerea	1	-	-	**1**
Artiodactyla	5	-	-	**5**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	4	-	-	**4**
Bison bison	1	-	-	**1**
Ovis canadensis	1	-	-	**1**
Total	**28**	**0**	**0**	**28**

Secondary Pit Structure 32				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	4	-	-	**4**
Sylvilagus sp.	11	-	-	**11**
Ondatra zibethicus	1	-	-	**1**
Erethizon dorsatum	1	-	-	**1**
Artiodactyla	10	-	-	**10**
Artiodactyl, Neonatal	1	-	-	**1**
Ovis canadensis	3	-	-	**3**
Odocoileus hemionus	6	-	-	**6**
Total	**37**	**0**	**0**	**37**

Pithouse 33				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	7	-	4	**11**
Lepus sp.	19	2	7	**28**
Sylvilagus sp.	188	7	23	**218**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	7	-	4	**11**
Sciuridae	2	-	-	**2**
Spermophilus variegatus	14	-	15	**29**
Thomomys sp.	4	3	3	**10**
Thomomys bottae	4	-	4	**8**
Perognathus sp.	1	-	-	**1**
Crecetinae	1	-	-	**1**
Neotoma cinerea	1	-	-	**1**
Neotoma lepida	5	-	-	**5**
Artiodactyla	32	2	9	**43**
Artiodactyl, Neonatal	8	-	1	**9**
Odocoileus hemionus	6	2	3	**11**
Ovis canadensis	7	-	-	**7**
Total	**308**	**16**	**73**	**397**

Storage Structure 34				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Artiodactyla	1	-	-	**1**
Peromyscus sp.	1	-	-	**1**
Total	**2**	**0**	**0**	**2**

Secondary Pit Structure 35				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	-	-	**2**
Sylvilagus sp.	20	-	-	**20**
Sylvilagus nuttallii	1	-	-	**1**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Odocoileus, Neonatal	1	-	-	**1**
Total	**26**	**0**	**0**	**26**

Pithouse 36				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	-	1	**3**
Lepus sp.	26	2	-	**28**
Sylvilagus sp.	234	38	37	**309**
Sylvilagus audubonii	-	-	1	**1**
Sylvilagus nuttallii	4	-	2	**6**
Rodentia	6	-	1	**7**
Sciuridae	2	1	-	**3**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	6	1	8	**15**
Thomomys bottae	7	2	1	**10**
Peromyscus sp.	-	1	-	**1**
Neotoma cinerea	2	-	-	**2**
Neotoma lepida	1	-	-	**1**
Erethizon dorsatum	2	-	-	**2**
Artiodactyla	25	3	2	**30**
Artiodactyl, Neonatal	10	-	6	**16**
Odocoileus hemionus	12	3	-	**15**
Odocoileus, Neonatal	1	-	-	**1**
Antilocapra americana	4	-	-	**4**
Bison bison	1	-	-	**1**
Ovis canadensis	9	-	-	**9**
Total	**355**	**51**	**59**	**465**

Storage Structure 37				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	6	1		**7**
Artiodactyla	4			**4**
Ovis canadensis	1			**1**
Total	**11**	**1**	**0**	**12**

Pithouse 38				
Taxon	**Fill**	**Floor**	**Subfloor feature**	**Total**
Leporidae	3	2	-	**5**
Lepus sp.	36	3	6	**45**
Sylvilagus sp.	237	48	32	**317**
Sylvilagus audubonii	3	1	-	**4**
Sylvilagus nuttallii	6	1	-	**7**
Rodentia	3	-	-	**3**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	6	-	1	**7**
Thomomys sp.	7	6	2	**15**
Thomomys bottae	10	-	-	**10**
Ondatra zibethicus	1	-	-	**1**
Canis sp.	2	-	-	**2**
Canis latrans	1	-	-	**1**
Artiodactyla	32	1	3	**36**
Artiodactyl, Neonatal	5	1	4	**10**
Odocoileus hemionus	4	1	1	**6**
Antilocapra americana	4	-	-	**4**
Bison bison	1	-	-	**1**
Ovis canadensis	5	-	-	**5**
Total	**367**	**64**	**49**	**480**

Secondary Pit Structure 39				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	5	-	-	**5**
Lepus sp.	12	-	-	**12**
Sylvilagus sp.	69	10	-	**79**
Sylvilagus nuttallii	1	-	-	**1**
Mustela frenata	1	-	-	**1**
Odocoileus, Neonatal	2	-	-	**2**
Rodentia	1	-	-	**1**
Spermophilus variegatus	3	-	-	**3**
Thomomys sp.	1	-	-	**1**
Artiodactyla	12	2	-	**14**
Artiodactyl, Neonatal	12	2	-	**14**
Odocoileus hemionus	2	-	-	**2**
Ovis canadensis	4	1	-	**5**
Total	**125**	**15**	**0**	**140**

Storage Structure 40				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Bison bison	3	-	-	3
Lepus sp.	4	-	-	4
Sylvilagus sp.	1	-	-	1
Rodentia	1	-	-	1
Artiodactyla	3	-	-	3
Total	12	0	0	12

Pithouse 41				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	6	-	-	**6**
Sylvilagus sp.	53	-	-	**53**
Sylvilagus nuttallii	1	-	-	**1**
Rodentia	3	-	-	**3**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Thomomys bottae	3	-	-	**3**
Artiodactyla	12	-	-	**12**
Artiodactyl, Neonatal	2	-	-	**2**
Odocoileus hemionus	3	-	-	**3**
Ovis canadensis	2	-	-	**2**
Total	**88**	**0**	**0**	**88**

Secondary Pit Structure 42				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	1			**1**
Odocoileus hemionus	1			**1**
Ovis canadensis	1			**1**
Total	**3**	**0**	**0**	**3**

Pithouse 43				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	-	1	-	**1**
Lepus sp.	22	6	1	**29**
Sylvilagus sp.	228	76	10	**314**
Sylvilagus audubonii	3	-	-	**3**
Sylvilagus nuttallii	3	-	-	**3**
Rodentia	4	12	1	**17**
Sciuridae	4	1	-	**5**
Marmota flaviventris	1	-	-	**1**
Spermophilus variegatus	2	-	2	**4**
Tamias sp.	1	-	-	**1**
Thomomys sp.	5	4	-	**9**
Thomomys bottae	20	9	2	**31**
Perognathus sp.	-	1	-	**1**
Peromyscus sp.	-	1	-	**1**
Neotoma cinerea	1	-	-	**1**
Canis sp.	1	-	-	**1**
Mustela frenata	1	-	-	**1**
Artiodactyla	21	5	5	**31**
Artiodactyl, Neonatal	1	2	-	**3**
Odocoileus hemionus	3	6	-	**9**
Odocoileus, Neonatal	4	4	-	**8**
Antilocapra americana	1	-	-	**1**
Bison bison	2	-	-	**2**
Ovis canadensis	8	3	-	**11**
Total	**336**	**131**	**21**	**488**

Secondary Pit Structure 44				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	1	-	-	**1**
Sylvilagus sp.	5	-	3	**8**
Artiodactyl, Neonatal	3	-	-	**3**
Total	**10**	**0**	**3**	**13**

Pithouse 45				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	16	2	-	**18**
Sylvilagus sp.	55	8	-	**63**
Sylvilagus nuttallii	-	1	-	**1**
Thomomys sp.	2	1	-	**3**
Artiodactyla	16	4	-	**20**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	3	6	-	**9**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	13	3	-	**16**
Total	**108**	**25**	**0**	**133**

Storage Structure 46				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	3	-	-	**3**
Sylvilagus sp.	13	-	-	**13**
Neotoma cinerea	1	-	-	**1**
Neotoma lepida	4	-	-	**4**
Microtus sp.	2	-	-	**2**
Mustela frenata	1	-	-	**1**
Artiodactyla	8	-	-	**8**
Odocoileus hemionus	9	-	-	**9**
Bison bison	1	-	-	**1**
Ovis canadensis	7	-	-	**7**
Total	**49**	**0**	**0**	**49**

Pithouse 47				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	4	4	**9**
Sylvilagus sp.	9	10	38	**59**
Sylvilagus nuttallii	-	1	1	**2**
Rodentia	1	-	1	**2**
Spermophilus variegatus	-	1	-	**1**
Thomomys sp.	1	-	-	**1**
Thomomys bottae	1	-	1	**2**
Castor canadensis	1	-	-	**1**
Ondatra zibethicus	1	-	-	**1**
Artiodactyla	2	1	4	**7**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	-	-	2	**2**
Total	**18**	**17**	**51**	**88**

Pithouse 48				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	4	-	-	**4**
Lepus sp.	7	3	2	**12**
Sylvilagus sp.	78	13	10	**101**
Sylvilagus audubonii	-	-	1	**1**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	2	-	-	**2**
Spermophilus variegatus	8	1	-	**9**
Thomomys sp.	5	-	-	**5**
Thomomys bottae	4	-	-	**4**
Neotoma lepida	1	-	-	**1**
Artiodactyla	28	1	1	**30**
Artiodactyl, Neonatal	5	1	-	**6**
Odocoileus hemionus	4	1	1	**6**
Odocoileus, Neonatal	1	-	-	**1**
Ovis canadensis	16	4	1	**21**
Total	**165**	**24**	**16**	**205**

Secondary Pit Structure 49				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	-	-	**2**
Lepus sp.	14	-	-	**14**
Sylvilagus sp.	40	-	2	**42**
Rodentia	2	-	-	**2**
Thomomys sp.	-	1	-	**1**
Thomomys bottae	1	-	-	**1**
Dipodomys sp.	1	-	-	**1**
Castor canadensis	1	-	-	**1**
Erethizon dorsatum	1	-	-	**1**
Lynx rufus	2	-	-	**2**
Artiodactyla	6	-	1	**7**
Artiodactyl, Neonatal	6	1	-	**7**
Odocoileus hemionus	4	-	-	**4**
Odocoileus, Neonatal	1	-	-	**1**
Ovis canadensis	5	-	-	**5**
Total	**86**	**2**	**3**	**91**

Secondary Pit Structure 50				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	-	-	2	**2**
Sylvilagus sp.	-	-	1	**1**
Total	**0**	**0**	**3**	**3**

Storage Structure 51				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	-	1	-	**1**
Sylvilagus sp.	1	1	-	**2**
Artiodactyla	1	2	-	**3**
Odocoileus hemionus	1	1	-	**2**
Total	**3**	**5**	**-**	**8**

Storage Structure 52				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	1	-	-	**1**
Odocoileus hemionus	3	-	-	**3**
Ovis canadensis	1	-	-	**1**
Total	**5**	**0**	**0**	**5**

Secondary Pit Structure 53				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Thomomys bottae	1	-	-	**1**
Total	**1**	**0**	**0**	**1**

Secondary Pit Structure 54				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	1	-	-	**1**
Artiodactyla	4	-	-	**4**
Artiodactyl, Neonatal	4	-	-	**4**
Ovis canadensis	1	-	-	**1**
Total	**12**	**0**	**0**	**12**

Secondary Pit Structure 55				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	12	-	-	**12**
Artiodactyla	1	-	-	**1**
Total	**1**	**0**	**0**	**33**

Pithouse 56				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	9	-	-	**9**
Lepus sp.	77	2	1	**80**
Sylvilagus sp.	407	27	37	**471**
Sylvilagus audubonii	6	1	1	**8**
Sylvilagus nuttallii	5	1	-	**6**
Rodentia	3	-	-	**3**
Spermophilus sp.	1	-	-	**1**
Spermophilus variegatus	4	-	1	**5**
Cynomys sp.	1	-	-	**1**
Thomomys sp.	24	1	-	**25**
Thomomys bottae	17	1	-	**18**
Ondatra zibethicus	-	1	-	**1**
Erethizon dorsatum	4	-	-	**4**
Ursus americanus	-	1	4	**5**
Lynx rufus	-	1	-	**1**
Artiodactyla	41	2	4	**47**
Artiodactyl, Neonatal	22	-	3	**25**
Odocoileus hemionus	26	-	1	**27**
Odocoileus, Neonatal	2	-	-	**2**
Bison bison	1	-	-	**1**
Ovis canadensis	27	-	-	**27**
Total	**677**	**38**	**52**	**767**

Pithouse 57				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	19	5	1	**25**
Lepus sp.	41	4	3	**48**
Sylvilagus sp.	286	73	12	**371**
Sylvilagus audubonii	4	-	-	**4**
Sylvilagus nuttallii	2	1	-	**3**
Rodentia	3	-	-	**3**
Sciuridae	-	1	-	**1**
Spermophilus variegatus	1	1	-	**2**
Tamias sp.	1	-	-	**1**
Thomomys sp.	10	1	1	**12**
Thomomys bottae	3	1	-	**4**
Peromyscus sp.	4	-	-	**4**
Neotoma cinerea	1	-	-	**1**
Ondatra zibethicus	3	-	-	**3**
Canis sp.	2	-	-	**2**
Mustela frenata	2	-	1	**3**
Artiodactyla	31	2	-	**33**
Artiodactyl, Neonatal	20	-	1	**21**
Odocoileus hemionus	27	-	-	**27**
Ovis canadensis	23	1	-	**24**
Total	**483**	**90**	**19**	**592**

Storage Structure 58				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	7	-	-	**7**
Sylvilagus audubonii	1	-	-	**1**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	1	-	-	**1**
Castor canadensis	2	-	-	**2**
Neotoma lepida	5	-	-	**5**
Ursus americanus	1	-	-	**1**
Mustela frenata	1	-	-	**1**
Artiodactyla	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	1	-	-	**1**
Total	**23**	**0**	**0**	**23**

Secondary Pit Structure 59				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	-	-	**2**
Lepus sp.	13	-	-	**13**
Sylvilagus sp.	30	-	1	**31**
Rodentia	1	-	-	**1**
Thomomys sp.	4	-	-	**4**
Thomomys bottae	2	-	-	**2**
Artiodactyla	5	-	-	**5**
Odocoileus hemionus	5	-	-	**5**
Ovis canadensis	3	-	-	**3**
Total	**65**	**0**	**1**	**66**

Pithouse 60				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	7	2	-	**9**
Sylvilagus sp.	32	13	5	**50**
Sylvilagus audubonii	1	-	1	**2**
Rodentia	1	1	-	**2**
Sciuridae	-	1	-	**1**
Spermophilus variegatus	1	2	-	**3**
Castor canadensis	1	-	-	**1**
Neotoma cinerea	-	1	-	**1**
Neotoma lepida	2	-	-	**2**
Erethizon dorsatum	3	3	-	**6**
Lynx rufus	1	-	-	**1**
Artiodactyla	47	21	-	**68**
Artiodactyl, Neonatal	1	1	-	**2**
Odocoileus hemionus	17	27	-	**44**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	14	15	-	**29**
Total	**129**	**87**	**6**	**222**

Pithouse 61				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	7	-	-	**7**
Lepus sp.	84	1	-	**85**
Sylvilagus sp.	407	17	8	**432**
Sylvilagus audubonii	6	-	1	**7**
Sylvilagus nuttallii	6	1	-	**7**
Rodentia	4	-	-	**4**
Spermophilus variegatus	3	-	-	**3**
Thomomys sp.	25	-	2	**27**
Thomomys bottae	9	-	-	**9**
Castor canadensis	2	-	-	**2**
Peromyscus sp.	1	-	-	**1**
Ondatra zibethicus	1	-	-	**1**
Erethizon dorsatum	3	-	-	**3**
Canis sp.	1	-	-	**1**
Canis latrans	1	-	-	**1**
Mustela frenata	1	-	-	**1**
Artiodactyla	164	7	8	**179**
Artiodactyl, Neonatal	7	1	1	**9**
Odocoileus hemionus	46	3	3	**52**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	25	2	-	**27**
Total	**804**	**32**	**23**	**859**

Secondary Pit Structure 62				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Chiroptera	-	1	-	**1**
Leporidae	-	3	-	**3**
Lepus sp.	-	17	22	**39**
Sylvilagus sp.	-	47	61	**108**
Sylvilagus audubonii	-	-	2	**2**
Sylvilagus nuttallii	-	1	1	**2**
Rodentia	-	1	1	**2**
Thomomys sp.	-	4	3	**7**
Thomomys bottae	-	4	4	**8**
Neotoma cinerea	-	-	1	**1**
Erethizon dorsatum	-	1	-	**1**
Canis sp.	-	2	-	**2**
Mustela frenata	-	1	-	**1**
Artiodactyla	-	31	6	**37**
Artiodactyl, Neonatal	-	5	5	**10**
Odocoileus hemionus	-	9	4	**13**
Odocoileus, Neonatal	-	4	1	**5**
Antilocapra americana	-	8	-	**8**
Ovis canadensis	-	12	1	**13**
Ovis, Neonatal	-	1	-	**1**
Total	**0**	**152**	**112**	**264**

Secondary Pit Structure 63				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Artiodactyla	-	-	5	**5**
Sylvilagus sp.	1	-	-	**1**
Ursus americanus	1	-	-	**1**
Total	**2**	**-**	**5**	**7**

Secondary Pit Structure 64				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	1	-	-	**1**
Total	**4**	**0**	**0**	**4**

Secondary Pit Structure 65				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	7	-	-	**7**
Thomomys sp.	1	-	-	**1**
Lynx rufus	1	-	-	**1**
Artiodactyla	2	-	-	**2**
Odocoileus hemionus	3	-	-	**3**
Ovis canadensis	1	-	-	**1**
Total	**15**	**0**	**0**	**15**

Secondary Pit Structure 66				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	1	-	-	**1**
Total	**3**	**0**	**0**	**3**

Pithouse 67				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	1	-	**3**
Lepus sp.	18	2	-	**20**
Sylvilagus sp.	65	9	2	**76**
Sylvilagus audubonii	-	1	-	**1**
Sylvilagus nuttallii	-	1	-	**1**
Spermophilus variegatus	1	-	-	**1**
Thomomys bottae	8	-	-	**8**
Thomomys sp.	7	-	-	**7**
Castor canadensis	8	-	-	**8**
Artiodactyla	13	1	-	**14**
Artiodactyl, Neonatal	-	-	2	**2**
Odocoileus hemionus	7	6	-	**13**
Odocoileus, Neonatal	-	1	-	**1**
Ovis canadensis	5	-	-	**5**
Total	**134**	**22**	**4**	**160**

Pithouse 68				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	10	-	-	**10**
Sylvilagus sp.	17	-	2	**19**
Sylvilagus nuttallii	1	-	-	**1**
Spermophilus variegatus	-	-	2	**2**
Thomomys bottae	2	-	-	**2**
Erethizon dorsatum	1	-	-	**1**
Artiodactyla	19	-	2	**21**
Odocoileus hemionus	6	-	-	**6**
Odocoileus, Neonatal	2	-	-	**2**
Ovis canadensis	12	-	-	**12**
Total	**70**	**0**	**6**	**76**

Pithouse 69				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	11	1	-	**12**
Thomomys sp.	1	-	-	**1**
Artiodactyla	5	3	-	**8**
Total	**19**	**4**	**0**	**23**

Pithouse 70				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	1	-	**3**
Lepus sp.	15	-	-	**15**
Sylvilagus sp.	67	10	3	**80**
Sylvilagus audubonii	2	-	-	**2**
Rodentia	5	3	-	**8**
Sciuridae	13	1	-	**14**
Spermophilus variegatus	1	-	-	**1**
Thomomys bottae	5	-	-	**5**
Artiodactyla	23	2	1	**26**
Odocoileus hemionus	14	-	-	**14**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	6	-	-	**6**
Total	**154**	**17**	**4**	**175**

Pithouse 71				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	1	1	**3**
Sylvilagus sp.	26	6	6	**38**
Sylvilagus nuttallii	1	-	-	**1**
Rodentia	4	1	-	**5**
Thomomys sp.	1	-	-	**1**
Thomomys bottae	9	-	-	**9**
Neotoma lepida	1	-	-	**1**
Ondatra zibethicus	1	-	-	**1**
Artiodactyla	11	2	-	**13**
Odocoileus hemionus	5	-	-	**5**
Ovis canadensis	-	-	2	**2**
Total	**60**	**10**	**9**	**79**

Storage Structure 72				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	4	-	-	**4**
Rodentia	1	-	1	**2**
Spermophilus variegatus	1	-	-	**1**
Thomomys bottae	1	-	-	**1**
Neotoma cinerea	3	-	-	**3**
Neotoma lepida	1	-	-	**1**
Microtus sp.	1	-	-	**1**
Microtus montanus	1	-	-	**1**
Artiodactyla	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	2	-	-	**2**
Total	**19**	**0**	**1**	**20**

Storage Structure 73				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Thomomys sp.	1	-	-	1
Artiodactyla	1	-	-	1
Odocoileus hemionus	1	-	-	1
Total	**12**	**0**	**0**	**12**

Pithouse 74				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	-	1	**2**
Sylvilagus sp.	52	7	-	**59**
Sylvilagus audubonii	1	1	-	**2**
Thomomys sp.	1	-	-	**1**
Ondatra zibethicus	1	-	-	**1**
Artiodactyla	13	-	-	**13**
Artiodactyl, Neonatal	3	-	-	**3**
Odocoileus hemionus	6	-	-	**6**
Ovis canadensis	2	-	-	**2**
Total	**80**	**8**	**1**	**89**

Pithouse 75				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	2	-	-	**2**
Lepus sp.	17	1	1	**19**
Sylvilagus sp.	98	6	6	**110**
Sylvilagus audubonii	1	-	-	**1**
Rodentia	12	-	-	**12**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	27	-	-	**27**
Thomomys bottae	7	-	-	**7**
Artiodactyla	39	14	1	**54**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	10	6	-	**16**
Bison bison	-	1	-	**1**
Ovis canadensis	18	6	-	**24**
Total	**233**	**34**	**8**	**275**

Secondary Pit Structure 76				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	2	-	-	**2**
Sylvilagus sp.	11	1	-	**12**
Rodentia	-	1	-	**1**
Spermophilus variegatus	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Ondatra zibethicus	2	-	-	**2**
Artiodactyla	1	-	-	**1**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	2	-	-	**2**
Total	**22**	**2**	**0**	**24**

Secondary Pit Structure 77				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Artiodactyla, Neonatal	2	-	-	**2**
Ovis canadensis	1	-	-	**1**
Thomomys sp.	1	-	-	**1**
Total	**4**	**0**	**0**	**4**

Pithouse 79				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	4	-	-	**4**
Lepus sp.	42	9	6	**57**
Sylvilagus sp.	154	36	20	**210**
Sylvilagus audubonii	3	1	1	**5**
Sylvilagus nuttallii	3	1	-	**4**
Rodentia	1	-	-	**1**
Sciuridae	1	-	-	**1**
Thomomys sp.	7	1	-	**8**
Thomomys bottae	12	1	-	**13**
Microtus sp.	1	-	-	**1**
Ondatra zibethicus	4	-	-	**4**
Artiodactyla	41	7	6	**54**
Artiodactyl, Neonatal	3	1	-	**4**
Odocoileus hemionus	14	3	2	**19**
Bison bison	5	2	-	**7**
Ovis canadensis	8	1	1	**10**

Total	**303**	**63**	**36**	**402**

Storage Structure 80				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	2	2	-	**4**
Sylvilagus audubonii	1	-	-	**1**
Rodentia	1	-	-	**1**
Artiodactyla	2	1	-	**3**
Ovis canadensis	-	1	-	**1**
Total	**6**	**4**	**0**	**10**

Pithouse 81				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	-	2	-	**2**
Sylvilagus sp.	8	2	3	**13**
Erethizon dorsatum	1	-	-	**1**
Artiodactyla	6	1	-	**7**
Odocoileus hemionus	1	-	-	**1**
Antilocapra americana	2	-	-	**2**
Ovis canadensis	3	-	-	**3**
Total	**21**	**5**	**3**	**29**

Activity Area 1				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	4	-	-	**4**
Sylvilagus sp.	16	-	-	**16**
Artiodactyla	3	-	-	**3**
Artiodactyl, Neonatal	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Ovis canadensis	3	-	-	**3**
Total	**28**	**0**	**0**	**28**

Activity Area 2				
Taxon	**Fill**	**Floor**	**Fill**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	1	-	-	**1**
Sylvilagus sp.	5	-	-	**5**
Rodentia	2	-	-	**2**
Marmota flaviventris	1	-	-	**1**
Artiodactyla	5	-	-	**5**
Artiodactyl, Neonatal	1	-	-	**1**
Ovis canadensis	3	-	-	**3**
Total	**19**	**0**	**0**	**19**

Activity Area 4				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	5	1	1	**7**
Erethizon dorsatum	1	-	-	**1**
Artiodactyla	5	-	-	**5**
Total	**11**	**1**	**1**	**13**

Activity Area 7				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	5	-	-	**5**
Lepus sp.	8	-	-	**8**
Sylvilagus sp.	26	-	-	**26**
Thomomys sp.	2	-	-	**2**
Artiodactyla	11	-	-	**11**
Artiodactyl, Neonatal	5	-	-	**5**
Odocoileus hemionus	2	-	-	**2**
Ovis canadensis	4	-	-	**4**
Total	**63**	**0**	**0**	**63**

Activity Area 8				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	5	2	-	**7**
Lepus sp.	46	3	-	**49**
Sylvilagus sp.	178	37	-	**215**
Sylvilagus nuttallii	-	1	-	**1**
Rodentia	1	-	-	**1**
Sciuridae	3	-	-	**3**
Spermophilus variegatus	25	-	-	**25**
Cynomys sp.	1	-	-	**1**
Thomomys sp.	3	1	-	**4**
Thomomys bottae	9	1	-	**10**
Erethizon dorsatum	1	-	-	**1**
Carnivora	4	-	-	**4**
Canis sp.	1	-	-	**1**
Canis latrans	1	-	-	**1**
Artiodactyla	59	4	-	**63**
Artiodactyl, Neonatal	4	-	-	**4**
Odocoileus hemionus	13	1	-	**14**
Odocoileus, Neonatal	1	-	-	**1**
Bison bison	1	-	-	**1**
Ovis canadensis	23	1	-	**24**
Total	**379**	**51**	**0**	**430**

Activity Area 9				
Taxon	**General fill**	**Floor**	**Subfloor**	**Total**
Leporidae	7	-	-	**7**
Lepus sp.	90	3	-	**93**
Sylvilagus sp.	384	7	-	**391**
Sylvilagus audubonii	3	-	-	**3**
Sylvilagus nuttallii	5	-	-	**5**
Rodentia	3	-	-	**3**
Sciuridae	2	-	-	**2**
Marmota flaviventris	4	-	-	**4**
Spermophilus variegatus	4	-	-	**4**
Thomomys sp.	9	-	-	**9**
Thomomys bottae	11	-	-	**11**
Erethizon dorsatum	4	-	-	**4**
Carnivora	1	-	-	**1**
Artiodactyla	130	-	-	**130**
Artiodactyl, Neonatal	15	1	-	**16**
Odocoileus hemionus	65	-	-	**65**
Odocoileus, Neonatal	10	-	-	**10**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	69	-	-	**69**
Total	**817**	**11**	**0**	**828**

Activity Area 10				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	2	2	-	**4**
Artiodactyl, Neonatal	1	-	-	**1**
Ovis canadensis	1	-	-	**1**
Total	**4**	**2**	**0**	**6**

Activity Area 11				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	-	-	2	**2**
Lepus sp.	1	-	3	**4**
Sylvilagus sp.	2	10	4	**16**
Sciuridae	-	1	-	**1**
Spermophilus variegatus	1	-	1	**2**
Artiodactyla	4	3	3	**10**
Artiodactyl, Neonatal	-	2	2	**4**
Total	**8**	**16**	**15**	**39**

Activity Area 12				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Lepus sp.	5	1	-	**6**
Sylvilagus sp.	3	2	-	**5**
Rodentia	1	-	-	**1**
Odocoileus hemionus	1	-	-	**1**
Total	**11**	**3**	**0**	**14**

Activity Area 13				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	5	4	-	**9**
Lepus sp.	28	6	-	**34**
Sylvilagus sp.	144	42	-	**186**
Sylvilagus audubonii	1	-	-	**1**
Sylvilagus nuttallii	1	-	-	**1**
Rodentia	-	1	-	**1**
Spermophilus variegatus	4	-	-	**4**
Thomomys bottae	1	1	-	**2**
Thomomys sp.	1	3	-	**4**
Neotoma lepida	1	-	-	**1**
Artiodactyla	22	10	-	**32**
Artiodactyl, Neonatal	19	7	-	**26**
Odocoileus hemionus	3	-	-	**3**
Odocoileus, Neonatal	4	3	-	**7**
Ovis canadensis	16	6	-	**22**
Total	**250**	**83**	**0**	**333**

Activity Area 14				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	10	-	-	**10**
Sylvilagus sp.	10	-	-	**10**
Thomomys sp.	1	-	-	**1**
Castor canadensis	1	-	-	**1**
Canis sp.	1	-	-	**1**
Artiodactyla	11	-	-	**11**
Artiodactyl, Neonatal	7	-	-	**7**
Odocoileus hemionus	6	-	-	**6**
Ovis canadensis	6	-	-	**6**
Total	**53**	**0**	**0**	**53**

Activity Area 16				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	1	-	-	**1**
Sylvilagus sp.	2	5	-	**7**
Thomomys sp.	1	-	-	**1**
Artiodactyla	2	2	-	**4**
Odocoileus hemionus	-	2	-	**2**
Total	**6**	**9**	**0**	**15**

Activity Area 18				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Sylvilagus sp.	-	1	-	**1**
Total	**0**	**2**	**0**	**2**

Activity Area 19				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Artiodactyla	-	1	-	**1**
Total	**0**	**1**	**0**	**1**

Activity Area 20				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	3	-	-	**3**
Sylvilagus sp.	11	-	1	**12**
Rodentia	1	-	-	**1**
Spermophilus variegatus	2	-	-	**2**
Thomomys sp.	1	-	-	**1**
Neotoma cinerea	2	-	-	**2**
Artiodactyla	4	-	-	**4**
Odocoileus hemionus	2	-	-	**2**
Ovis canadensis	5	-	-	**5**
Total	**31**	**0**	**1**	**32**

Activity Area 21				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Artiodactyla, Neonatal	1	-	-	**1**
Total	**6**	**0**	**0**	**6**

Activity Area 24				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	63	13	-	**76**
Sylvilagus sp.	173	15	-	**188**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	1	-	-	**1**
Spermophilus sp.	-	1	-	**1**
Spermophilus variegatus	6	-	-	**6**
Thomomys bottae	6	4	-	**10**
Thomomys sp.	12	1	-	**13**
Castor canadensis	-	1	-	**1**
Microtus sp.	1	-	-	**1**
Ondatra zibethicus	7	1	-	**8**
Erethizon dorsatum	2	-	-	**2**
Canis sp.	2	-	-	**2**
Canis latrans	1	-	-	**1**
Artiodactyla	46	10	-	**56**
Artiodactyl, Neonatal	8	3	-	**11**
Odocoileus hemionus	19	-	-	**19**
Odocoileus, Neonatal	1	-	-	**1**
Ovis canadensis	17	3	-	**20**
Ovis, Neonatal	3	-	-	**3**
Total	**370**	**52**	**0**	**422**

Activity Area 25				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	6	-	34	**40**
Sylvilagus sp.	15	-	98	**113**
Sylvilagus nuttallii	-	-	2	**2**
Rodentia	-	-	1	**1**
Spermophilus variegatus	-	-	1	**1**
Perognathus sp.	1	-	-	**1**
Thomomys sp.	7	-	22	**29**
Thomomys bottae	7	-	15	**22**
Castor canadensis	-	-	1	**1**
Microtus sp.	1	-	1	**2**
Ondatra zibethicus	-	-	3	**3**
Erethizon dorsatum	-	-	1	**1**
Canis sp.	-	-	3	**3**
Lynx canadensis	-	-	1	**1**
Artiodactyla	5	1	36	**42**
Artiodactyl, Neonatal	1	-	20	**21**
Odocoileus hemionus	-	-	18	**18**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	3	-	10	**13**
Total	**47**	**1**	**267**	**315**

Activity Area 27				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	-	1	-	**1**
Lepus sp.	-	8	-	**8**
Sylvilagus sp.	-	6	-	**6**
Spermophilus sp.	-	1	-	**1**
Spermophilus variegatus	-	1	-	**1**
Thomomys sp.	-	2	-	**2**
Thomomys bottae	-	1	-	**1**
Lynx rufus	-	1	-	**1**
Artiodactyla	-	6	-	**6**
Odocoileus hemionus	-	4	-	**4**
Odocoileus, Neonatal	-	1	-	**1**
Ovis canadensis	-	1	-	**1**
Total	**0**	**33**	**0**	**33**

Activity Area 28				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	4	-	-	**4**
Lepus sp.	71	-	-	**71**
Sylvilagus sp.	214	-	-	**214**
Sylvilagus audubonii	2	-	-	**2**
Sylvilagus nuttallii	3	-	-	**3**
Rodentia	1	-	-	**1**
Spermophilus sp.	5	-	-	**5**
Spermophilus variegatus	5	-	-	**5**
Thomomys sp.	26	-	-	**26**
Thomomys bottae	12	-	-	**12**
Castor canadensis	4	-	-	**4**
Ondatra zibethicus	2	-	-	**2**
Erethizon dorsatum	1	-	-	**1**
Carnivora	1	-	-	**1**
Artiodactyla	78	-	-	**78**
Artiodactyl, Neonatal	13	-	-	**13**
Odocoileus hemionus	38	1	-	**39**
Odocoileus, Neonatal	1	-	-	**1**
Antilocapra americana	1	-	-	**1**
Ovis canadensis	37	-	-	**37**
Total	**519**	**1**	**0**	**520**

Activity Area 29				
Taxon	**Fill**	**Floor**	**Floor**	**Total**
Lepus sp.	-	10	-	**10**
Sylvilagus sp.	-	26	-	**26**
Spermophilus sp.	-	1	-	**1**
Thomomys sp.	-	2	-	**2**
Thomomys bottae	-	1	-	**1**
Castor canadensis	-	2	-	**2**
Artiodactyla	-	18	-	**18**
Artiodactyl, Neonatal	-	4	-	**4**
Odocoileus hemionus	-	5	-	**5**
Ovis canadensis	-	14	-	**14**
Total	**0**	**83**	**0**	**83**

Activity Area 30				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Lepus sp.	6	-	-	**6**
Sylvilagus sp.	8	-	-	**8**
Sylvilagus audubonii	1	-	-	**1**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	3	-	-	**3**
Thomomys bottae	1	-	-	**1**
Castor canadensis	2	-	-	**2**
Artiodactyla	10	-	-	**10**
Ovis canadensis	5	-	-	**5**
Total	**37**	**0**	**0**	**37**

Activity Area 32				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	1	-	-	**1**
Sylvilagus sp.	7	-	-	**7**
Artiodactyl, Neonatal	2	-	-	**2**
Total	**10**	**0**	**0**	**10**

Unknown C				
Taxon	**Fill**	**Floor**	**Subfloor**	**Total**
Leporidae	10	-	-	**10**
Lepus sp.	32	-	-	**32**
Sylvilagus sp.	94	-	-	**94**
Sylvilagus nuttallii	2	-	-	**2**
Rodentia	1	-	-	**1**
Sciuridae	1	-	-	**1**
Spermophilus variegatus	2	-	-	**2**
Peromyscus sp.	1	-	-	**1**
Thomomys sp.	5	-	-	**5**
Thomomys bottae	4	-	-	**4**
Artiodactyla	7	-	-	**7**
Artiodactyl, Neonatal	2	-	-	**2**
Odocoileus hemionus	4	-	-	**4**
Odocoileus, Neonatal	1	-	-	**1**
Ovis canadensis	1	-	-	**1**
Total	**167**	**0**	**0**	**167**

Appendix B:

ARTIODACTYL NISP & MNE VALUES PER PROVENIENCE

The following tables provide the number of individual specimens (NISP) and minimum number of elements (MNE) values for structure and activity area contexts at Five Finger Ridge. MNE values were derived visually to determine if multiple specimens from the same contexts shared landmark features of skeletal elements. Values were computed for *Ovis* and *Odocoileus*, as well as for unassigned artiodactyls. As such, specimens identified as unassigned artiodactyl originally may have come from the same individual animal as specimens identified to the species level, and comparisons of MNE values should be made only between *Ovis* and *Odocoileus*. Neonatal artiodactyl specimens are excluded.

ST 1, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 1, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 2 , Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1	1	1
Mandible						
Tooth			1	1		
Atlas						
Axis						
Cervical					1	1
Thoracic					1	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					3	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal	1	1				
Metacarpal					1	1
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			2	2		

ST 2, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal	1	1				
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 3, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1	13	1	4	1
Mandible						
Tooth			1	1		
Atlas					3	1
Axis					2	1
Cervical					4	2
Thoracic					4	1
Lumbar					6	3
Sacrum						
Caudal						
Rib					24	5
Sternum						
Scapula						
Humerus	1	1	1	1	5	2
Radius/Ulna	1	1			1	1
Carpal	4	4				
Metacarpal	1	1	3	2		
Innominate	2	1	1	1	4	1
Femur					3	2
Tibia	2	2	1	1	8	2
Fibula						
Astragalus	1	1			1	1
Calcaneus			3	3	1	1
Tarsal	1	1				
Metatarsal	2	1	1	1		
Phalanges	10	8	15	10	6	6

ST 3, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible			4	2		
Tooth						
Atlas					1	1
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna	1	1	2	2	1	1
Carpal						
Metacarpal			3	1		
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus	1	1				
Tarsal						
Metatarsal	3	1	1	1		
Phalanges	1	1			1	1

ST 4, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	3	1				
Mandible	1	1				
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					4	1
Sternum						
Scapula			1	1		
Humerus			1	1		
Radius/Ulna	2	1				
Carpal			1	1		
Metacarpal						
Innominate	1	1				
Femur					3	1
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			3	1		
Phalanges						

ST 5, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula						
Humerus					4	3
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges	1	1				

ST 5, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible			2	1		
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 7, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth	1	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 8, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges	1	1				

ST 9, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis					1	1
Cervical					1	1
Thoracic						
Lumbar					1	1
Sacrum					1	1
Caudal						
Rib						
Sternum						
Scapula						
Humerus					3	3
Radius/Ulna			1	1	1	1
Carpal			1	1		
Metacarpal	2	1	2	1	1	1
Innominate					1	1
Femur						
Tibia			1	1	1	1
Fibula						
Astragalus	1	1				
Calcaneus			1	1	1	1
Tarsal	1	1	1	1		
Metatarsal	1	1				
Phalanges						

ST 9, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1		
Mandible			1	1		
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate			3	1		
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 11, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 13, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth					1	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					2	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges						

ST 13, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth					1	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					3	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal			7	2		
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1	1	1		
Phalanges					1	1

ST 14, Fill

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible			1	1		
Tooth	4	2	2	2	6	1
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula					1	1
Humerus					1	1
Radius/Ulna					1	1
Carpal						
Metacarpal					1	1
Innominate					1	1
Femur			1	1		
Tibia	2	2				
Fibula						
Astragalus						
Calcaneus			1	1		
Tarsal						
Metatarsal	1	1			1	1
Phalanges			1	1	3	2

ST 14, Floor

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth	2	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula					1	1
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges						

ST 15, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1		

ST 16, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					2	2
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 16, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth	1	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
ibia			1	1		
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 17, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible			1	1		
Tooth	1	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					9	
Sternum						
Scapula						
Humerus			2	2	4	1
Radius/Ulna			1	1		
Carpal					1	1
Metacarpal			1	1		
Innominate						
Femur			1	1	6	2
Tibia			3	2	4	2
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			1	1		
Phalanges					1	1

ST 17, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	4	1	1	1		
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					5	2
Sternum						
Scapula						
Humerus						
Radius/Ulna			3	2		
Carpal						
Metacarpal			1	1		
Innominate						
Femur					2	1
Tibia			3	3	2	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			1	1		
Phalanges					1	1

ST 19, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus			1	1		
Radius/Ulna			1	1		
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 20, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas					1	1
Axis						
Cervical						
Thoracic					1	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					10	1
Sternum						
Scapula						
Humerus	1	1			1	1
Radius/Ulna			1	1		
Carpal						
Metacarpal						
Innominate						
Femur					2	1
Tibia			1	1	2	1
Fibula						
Astragalus					1	1
Calcaneus						
Tarsal						
Metatarsal	1	1			1	1
Phalanges	1	1	1	1	1	1

ST 20, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	3	1				
Mandible					1	1
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1		

ST 21, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible			2	2		
Tooth					1	1
Atlas						
Axis						
Cervical					3	
Thoracic						
Lumbar					3	
Sacrum					1	1
Caudal						
Rib					7	
Sternum						
Scapula			1	1		
Humerus	1	1	1	1	5	1
Radius/Ulna	3	1			2	2
Carpal	1	1	1	1		
Metacarpal			3	1		
Innominate			2	2	1	1
Femur					4	1
Tibia					8	4
Fibula						
Astragalus						
Calcaneus	1	1				
Tarsal						
Metatarsal	3	1				
Phalanges			5		4	

ST 21, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas			1	1		
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula			1	1		
Humerus						
Radius/Ulna	1	1				
Carpal						
Metacarpal	1	1				
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 22, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			5	1	4	1
Mandible			1	1	1	1
Tooth	2	1	1	1	5	1
Atlas						
Axis						
Cervical					9	2
Thoracic					6	2
Lumbar					7	2
Sacrum					1	1
Caudal						
Rib					18	4
Sternum						
Scapula			2	2		
Humerus			2	1	4	2
Radius/Ulna	2	1	5	2	2	1
Carpal						
Metacarpal	2	1	3	1		
Innominate					2	2
Femur	1	1			3	2
Tibia					4	2
Fibula						
Astragalus			1	1		
Calcaneus	1	1	2			
Tarsal	1	1	1	1		
Metatarsal	3	1	1	1	1	1
Phalanges					2	1

ST 22, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1	2	1
Mandible						
Tooth					1	1
Atlas						
Axis			2	2		
Cervical					2	1
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna			5	2		
Carpal						
Metacarpal			7	2	1	1
Innominate	1	1	1	1		
Femur						
Tibia	1	1				
Fibula						
Astragalus						
Calcaneus	1	1			1	1
Tarsal						
Metatarsal						
Phalanges						

ST 23, Fill

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna	1	1				
Carpal			1	1		
Metacarpal						
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus	1	1				
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1		

ST 23, Floor

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible	1	1				
Tooth					1	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus	1	1				
Radius/Ulna	1	1				
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges						

ST 24, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1	1	1		
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula			1	1		
Humerus					3	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal	1	1			1	1
Metatarsal	1	1				
Phalanges			1	1		

ST 24, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth	1	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate					1	1
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1		

ST 25, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula			2	1		
Humerus						
Radius/Ulna						
Carpal						
Metacarpal			1	1		
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 26, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1	2	1	1	1
Mandible			1	1	1	1
Tooth	1	1	10	5	1	1
Atlas					1	1
Axis					3	2
Cervical					5	3
Thoracic					5	2
Lumbar					5	2
Sacrum						
Caudal						
Rib					8	2
Sternum						
Scapula			1	1		
Humerus	1	1			1	1
Radius/Ulna	3	2	4	2	3	2
Carpal			1	1		
Metacarpal			3	2	1	1
Innominate	1	1	3	2	2	2
Femur	1	1	1	1	5	1
Tibia	2	2	2	2	6	2
Fibula						
Astragalus			1	1		
Calcaneus	2	2	1	1	2	2
Tarsal			1	1		
Metatarsal	2	1			1	1
Phalanges	3	3	6	5	1	1

ST 26, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth	1	1				
Atlas						
Axis						
Cervical					1	1
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal	1	1				
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 27, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium					1	1
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna			1	1		
Carpal						
Metacarpal					1	1
Innominate					1	1
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges			2	2		

ST 27, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula					1	1
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 28, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	3	1	3	1	1	1
Mandible	1	1	1	1		
Tooth	1	1	2	2	3	1
Atlas			3	3	1	1
Axis			1	1	1	1
Cervical					4	2
Thoracic					14	5
Lumbar						
Sacrum	1	1	1	1	3	2
Caudal						
Rib					24	1
Sternum						
Scapula	1	1	1	1	2	2
Humerus			1	1	4	2
Radius/Ulna	3	3	7	4	3	1
Carpal						
Metacarpal	2	2	3	2	2	1
Innominate	2	2	3	2	3	2
Femur			4	2	10	3
Tibia	4	3	2	2	12	3
Fibula						
Astragalus	4	4	1	1		
Calcaneus	2	2	2	2	1	1
Tarsal	2	2	2	2		
Metatarsal	3	2	1	1		
Phalanges	1	1	12	11	1	1

ST 28, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1			1	1
Mandible			3	3	1	1
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic					3	1
Lumbar					3	1
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna			2	1		
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia					2	1
Fibula						
Astragalus	1	1				
Calcaneus						
Tarsal						
Metatarsal	2	1				
Phalanges	1	1	1	1	1	1

ST 29, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			4	1	6	1
Mandible			1	1	2	2
Tooth	4	2	6	6	10	2
Atlas						
Axis						
Cervical					2	1
Thoracic						
Lumbar					4	1
Sacrum						
Caudal					1	1
Rib					3	
Sternum					1	1
Scapula			1	1		
Humerus	1	1	3	2	2	2
Radius/Ulna			2	2	1	1
Carpal			2	2		
Metacarpal	1	1	2	2	1	1
Innominate	2	2			3	2
Femur			2	1	5	2
Tibia	1	1	4	3	4	1
Fibula						
Astragalus	1	1	2	2		
Calcaneus	2	2				
Tarsal	1	1				
Metatarsal	2	1	2	2		
Phalanges			1	1	1	1

ST 29, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium					2	1
Mandible			1	1		
Tooth	1		2	1		
Atlas						
Axis						
Cervical						
Thoracic					2	2
Lumbar					3	1
Sacrum						
Caudal						
Rib					5	2
Sternum						
Scapula					1	1
Humerus						
Radius/Ulna			1	1		
Carpal					1	1
Metacarpal	1	1	1	1		
Innominate						
Femur			1	1	2	2
Tibia					3	2
Fibula						
Astragalus						
Calcaneus	1	1	1	1	1	1
Tarsal			3	3		
Metatarsal	2		1	1	1	1
Phalanges	1	1	4	4		

ST 30, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	3	1	1	1	1	1
Mandible						
Tooth	2	2			2	2
Atlas						
Axis						
Cervical					5	3
Thoracic					11	3
Lumbar					2	1
Sacrum						
Caudal						
Rib					7	2
Sternum					1	1
Scapula					5	1
Humerus	1	1	4	2	3	2
Radius/Ulna			2	2	1	1
Carpal			1	1		
Metacarpal	1	1	3	2		
Innominate			1	1	2	1
Femur						
Tibia	1	1	1	1	2	1
Fibula						
Astragalus	1	1	1	1		
Calcaneus			1	1		
Tarsal	1	1	1	1		
Metatarsal	9	1	3	1	1	1
Phalanges			4	4	4	2

ST 30, Floor

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	7	1			1	1
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar					1	1
Sacrum					1	1
Caudal						
Rib					3	2
Sternum						
Scapula						
Humerus			1	1	2	1
Radius/Ulna	1	1				
Carpal			1	1		
Metacarpal					1	1
Innominate			2	1		
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus					1	1
Tarsal					2	2
Metatarsal	5	1			2	1
Phalanges	2	1	1	1	1	1

ST 31, Fill

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	3	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus	1	1			1	1
Radius/Ulna					1	1
Carpal						
Metacarpal			1	1		
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 32, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible	2	1	2	2		
Tooth	1	1	1	1	3	1
Atlas						
Axis					1	1
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus	1	1				
Tarsal						
Metatarsal	1	1				
Phalanges	1	1				

ST 33, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1	2	1
Mandible						
Tooth	2	2			1	1
Atlas			1	1		
Axis						
Cervical					1	1
Thoracic					4	2
Lumbar					2	1
Sacrum						
Caudal						
Rib					4	3
Sternum						
Scapula						
Humerus	1	1	2	1	3	2
Radius/Ulna						
Carpal			1	1	1	1
Metacarpal						
Innominate					6	
Femur	2	2			2	2
Tibia					2	1
Fibula						
Astragalus						
Calcaneus					2	2
Tarsal						
Metatarsal						
Phalanges	1	1	1	1	1	1

ST 33, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia	1	1			1	1
Fibula						
Astragalus	1	1				
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 34, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 36, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1	1	1		
Mandible			1	1	1	1
Tooth	5	3	2	2	2	1
Atlas						
Axis					1	1
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula					2	1
Humerus					3	2
Radius/Ulna					3	1
Carpal						
Metacarpal	1	1	1	1	1	1
Innominate					1	1
Femur					2	2
Tibia	1	1			4	2
Fibula						
Astragalus						
Calcaneus	1	1	1	1	1	1
Tarsal	1	1				
Metatarsal	2	1			1	1
Phalanges	1	1	1	1	1	1

ST 36, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula					1	1
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges						

ST 37, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal			1	1		
Metacarpal						
Innominate						
Femur					1	1
Tibia					2	2
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 38, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1		
Mandible	1	1				
Tooth			1	1		
Atlas						
Axis						
Cervical					2	1
Thoracic					1	1
Lumbar					3	1
Sacrum						
Caudal						
Rib					13	3
Sternum						
Scapula						
Humerus					3	1
Radius/Ulna	1	1			1	1
Carpal						
Metacarpal			1	1		
Innominate					1	1
Femur						
Tibia			1	1	3	1
Fibula						
Astragalus	1	1				
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges			1	1	3	3

ST 38, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal	1	1				
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 39, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium					1	1
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic					2	2
Lumbar					2	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus	1	1	1	1		
Radius/Ulna						
Carpal			2	2		
Metacarpal	1	1				
Innominate					1	1
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1	1	1

ST 39, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			1	1		
Phalanges						

ST 40, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula					1	1
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 41, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1			1	1
Mandible						
Tooth					1	1
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					3	1
Sternum						
Scapula						
Humerus	1	1			1	1
Radius/Ulna						
Carpal						
Metacarpal	1	1	2	1		
Innominate						
Femur					1	1
Tibia					3	2
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 42, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus			1	1		
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 43, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible					1	1
Tooth			1	1	2	1
Atlas					1	1
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum					1	1
Caudal						
Rib					7	1
Sternum						
Scapula						
Humerus						
Radius/Ulna			3	2	3	2
Carpal	1	1				
Metacarpal			1	1		
Innominate						
Femur			1	1	1	1
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges	1	1	2	2	3	3

ST 43, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible						
Tooth	4	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal			1	1		
Metacarpal			1	1		
Innominate						
Femur	1	1				
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1	1	1

ST 45, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium					1	1
Mandible			1	1		
Tooth	2	2	1	1	4	1
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna					2	1
Carpal						
Metacarpal			8	1		
Innominate						
Femur					2	
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1	3	1		
Phalanges	1	1	1	1	2	2

ST 45, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1		
Mandible						
Tooth			1	1	1	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia	1	1				
Fibula						
Astragalus	1	1				
Calcaneus					1	1
Tarsal	3					
Metatarsal	1	1				
Phalanges			1	1		

ST 46, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible	1	1				
Tooth			1	1		
Atlas						
Axis			1	1		
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					6	2
Sternum						
Scapula	1	1				
Humerus	2	2				
Radius/Ulna	1	1				
Carpal	2	2				
Metacarpal			1	1	1	1
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1	1	1		
Phalanges			2	2		

ST 47, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal					1	1
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges					1	1

ST 47, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 48, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible						
Tooth			1	1		
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					2	1
Radius/Ulna						
Carpal			1	1		
Metacarpal			5	1	2	1
Innominate					12	1
Femur						
Tibia						
Fibula						
Astragalus					1	1
Calcaneus						
Tarsal						
Metatarsal	3	1	8	1	2	1
Phalanges			1	1		

ST 48, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal					1	1
Rib						
Sternum						
Scapula			1	1		
Humerus						
Radius/Ulna						
Carpal						
Metacarpal			1	1		
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			2	1		
Phalanges						

ST 49, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1			1	1
Mandible						
Tooth			2	2		
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal			1	1		
Metacarpal	1	1				
Innominate			1	1	2	2
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges			1	1		

ST 49, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 51, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 51, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia	1	1				
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 52, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna	1	1				
Carpal	2	2				
Metacarpal						
Innominate						
Femur						
Tibia			1	1		
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 54, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate					1	1
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 54, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium					1	1
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal			1	1		
Metatarsal						
Phalanges						

ST 55, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 56, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1	2	1		
Mandible			2	1		
Tooth	3	3	1	1	1	1
Atlas					1	1
Axis						
Cervical					2	1
Thoracic					5	2
Lumbar					1	1
Sacrum						
Caudal						
Rib					10	4
Sternum						
Scapula	1	1	1	1	1	1
Humerus	3	3	2	2	5	4
Radius/Ulna	1	1	6	3	3	
Carpal						
Metacarpal	2	1	2	1		
Innominate			2	1	2	2
Femur			2	2	3	1
Tibia			2	2	5	2
Fibula						
Astragalus	2	2				
Calcaneus	2	2				
Tarsal	3	3	1	1	1	1
Metatarsal	1	1	2	1	1	1
Phalanges	4	4	3	3	1	1

ST 56, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 57, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1	2	1		
Mandible	2	1	1	1		
Tooth	5	2	1	1		
Atlas			2	2		
Axis						
Cervical						
Thoracic					4	3
Lumbar					1	1
Sacrum						
Caudal					1	1
Rib					5	2
Sternum						
Scapula	1	1	2	2	1	1
Humerus	2	2			1	1
Radius/Ulna	2	1	2	1	1	1
Carpal			2	2		
Metacarpal	2	1	2	1	3	1
Innominate	3		1	1		
Femur	1	1	1	1	3	1
Tibia	1	1			5	2
Fibula						
Astragalus	2	2				
Calcaneus	2	2				
Tarsal						
Metatarsal	1	1	2	2	1	1
Phalanges	3		4		1	1

ST 57, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			1	1	1	1
Phalanges						

ST 58, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula					1	1
Humerus	1	1	1	1		
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 59, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula						
Humerus	2	2			1	1
Radius/Ulna			1	1		
Carpal						
Metacarpal	1	1				
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1	1	1		
Phalanges	1	1	1	1		

ST 60, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	4	1			3	1
Mandible						
Tooth					3	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula			2	2		
Humerus					1	1
Radius/Ulna			2	2		
Carpal						
Metacarpal					3	1
Innominate					1	1
Femur					3	2
Tibia	4	1			6	2
Fibula						
Astragalus	1	1				
Calcaneus	1	1	1	1		
Tarsal	1	1	3	3	1	1
Metatarsal	6	1	5	3	1	1
Phalanges			1	1		

ST 60, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					4	2
Sacrum					1	1
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal	1	1				
Metacarpal	6	2	1	1	1	1
Innominate						
Femur						
Tibia			2	1	6	2
Fibula						
Astragalus			1	1	1	1
Calcaneus			3	2	1	1
Tarsal			1	1		
Metatarsal	19	1	7	1	2	1
Phalanges						

ST 61, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	2	1			5	1
Mandible	1	1	1	1		
Tooth	4	3	1	1		
Atlas					4	2
Axis					1	1
Cervical					5	3
Thoracic					13	3
Lumbar					15	8
Sacrum					1	1
Caudal						
Rib					35	13
Sternum						
Scapula	2	2	1	1		
Humerus	2	2	1	1	16	5
Radius/Ulna	6	3			6	1
Carpal	2	2	2	2		
Metacarpal	4	1	5	3	2	1
Innominate	1	1	3	3	11	6
Femur					9	3
Tibia	2	1	2	1	21	5
Fibula						
Astragalus	2	2	1	1		
Calcaneus	4	2	1	1		
Tarsal	1	1	1	1		
Metatarsal	4	2	2	1	3	1
Phalanges	8	8	3	3	7	6

ST 61, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1		
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum					1	1
Scapula						
Humerus						
Radius/Ulna						
Carpal	1	1				
Metacarpal			1	1		
Innominate						
Femur	2	1			1	1
Tibia					2	2
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges					1	1

ST 62, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 62, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium			3	1	1	1
Mandible	1	1				
Tooth			2	1		
Atlas						
Axis						
Cervical					2	2
Thoracic					2	2
Lumbar					2	1
Sacrum						
Caudal						
Rib					5	1
Sternum						
Scapula			1	1	4	2
Humerus	1	1	1	1	2	2
Radius/Ulna			2	1	6	2
Carpal						
Metacarpal						
Innominate	1	1	1	1		
Femur	1	1				
Tibia			2	2	3	2
Fibula						
Astragalus	1	1				
Calcaneus					1	1
Tarsal						
Metatarsal	3	2	1	1		
Phalanges	1	1			1	1

ST 65, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula	1	1				
Humerus	1	1			1	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia			1	1		
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 67, Fill

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible	1	1				
Tooth						
Atlas						
Axis						
Cervical					3	2
Thoracic					1	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					3	1
Sternum						
Scapula						
Humerus					2	1
Radius/Ulna						
Carpal						
Metacarpal			1	1		
Innominate					2	2
Femur			1	1		
Tibia	2	1	1	1		
Fibula						
Astragalus						
Calcaneus	1	1				
Tarsal	2	1				
Metatarsal	1	1	1	1		
Phalanges			1	1		

ST 67, Floor

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth	1	1				
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia	2	1			1	1
Fibula						
Astragalus	1	1				
Calcaneus	1	1				
Tarsal	1	1				
Metatarsal						
Phalanges						

ST 68, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis			1	1		
Cervical					3	
Thoracic					1	1
Lumbar					4	
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus	1	1	1	1	3	
Radius/Ulna					2	
Carpal						
Metacarpal	1	1				
Innominate					1	1
Femur						
Tibia	1	1			1	1
Fibula						
Astragalus						
Calcaneus	1	1	4	4		
Tarsal	1	1				
Metatarsal			2	2		
Phalanges			4	4	2	2

ST 69, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur					3	2
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges					1	1

ST 69, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate					1	1
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges					1	1

ST 70, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	1	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					2	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					4	2
Sternum						
Scapula					1	1
Humerus	1	1			2	1
Radius/Ulna	2	1	2	1	4	2
Carpal	1	1				
Metacarpal						
Innominate	1	1				
Femur			1	1	6	2
Tibia	3	2	1	1		
Fibula						
Astragalus						
Calcaneus			2	2		
Tarsal						
Metatarsal	1	1				
Phalanges	4	4			1	1

ST 70, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal					1	1
Phalanges						

ST 71, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis	1	1				
Cervical						
Thoracic					2	2
Lumbar						
Sacrum						
Caudal						
Rib					3	1
Sternum						
Scapula						
Humerus	1	1			1	1
Radius/Ulna					2	2
Carpal						
Metacarpal	2	2			1	1
Innominate						
Femur					2	2
Tibia					2	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1			1	1
Phalanges	3	3			2	1

ST 71, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal					1	1
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 72, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth					2	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal			1	1		
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 72, Floor

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges						

ST 73, Fill

Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus	1	1				
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 74, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth	1	1				
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					3	2
Sternum						
Scapula					1	1
Humerus	1	1				
Radius/Ulna						
Carpal	1	1	1	1		
Metacarpal						
Innominate					1	1
Femur					2	2
Tibia					4	1
Fibula						
Astragalus						
Calcaneus						
Tarsal	1	1				
Metatarsal	1	1				
Phalanges	1	1	1	1		

ST 75, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible			1	1	2	1
Tooth	4	4	2	1	1	1
Atlas	1	1				
Axis						
Cervical					1	1
Thoracic					1	1
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula					8	2
Humerus					2	2
Radius/Ulna	1	1	2	1	4	2
Carpal	1	1	1	1		
Metacarpal			3	2	1	1
Innominate						
Femur						
Tibia			1	1	5	1
Fibula						
Astragalus			1	1	1	1
Calcaneus			1	1	1	1
Tarsal			2	2		
Metatarsal			1	1		
Phalanges	3	3	2	2	6	2

ST 75, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible	5	2			1	1
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula					1	1
Humerus						
Radius/Ulna			4	2	3	2
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus					1	1
Tarsal						
Metatarsal			2	1		
Phalanges	1	1			1	1

ST 76, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus	1	1				
Radius/Ulna			1	1		
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges			1	1		

ST 77, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia			1	1		
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 79, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	6	1			3	1
Mandible	1	1				
Tooth						
Atlas						
Axis						
Cervical					2	1
Thoracic					2	2
Lumbar					6	2
Sacrum					1	1
Caudal						
Rib					9	1
Sternum						
Scapula	1	1			1	1
Humerus			1	1	3	2
Radius/Ulna					2	2
Carpal	1	1				
Metacarpal	3	1				
Innominate			2	2	3	2
Femur					2	1
Tibia						
Fibula						
Astragalus						
Calcaneus			1	1		
Tarsal						
Metatarsal			1	1		
Phalanges	2	2	1	1	2	2

ST 79, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium					1	1
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					2	1
Sternum						
Scapula						
Humerus						
Radius/Ulna	1	1			1	1
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			1	1		
Phalanges	2	2				

ST 80, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible					1	1
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 80, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible			1	1		
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

ST 81, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible					1	1
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					2	1
Radius/Ulna	1	1	1	1		
Carpal						
Metacarpal					1	1
Innominate						
Femur						
Tibia						
Fibula						
Astragalus					1	1
Calcaneus						
Tarsal						
Metatarsal			1	1		
Phalanges						

ST 81, Floor

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 1, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna			1	1		
Carpal			1	1	1	1
Metacarpal	1	1				
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 2 , Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth					1	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus			1	1		
Radius/Ulna						
Carpal						
Metacarpal						
Innominate					2	2
Femur					1	1
Tibia					1	1
Fibula						
Astragalus						
Calcaneus			1	1		
Tarsal						
Metatarsal						
Phalanges			1	1		

AA 4, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth					1	1
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal					1	1
Metatarsal					1	1
Phalanges						

AA 7, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth			1	1	2	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					2	2
Radius/Ulna			1	1		
Carpal			1	1		
Metacarpal						
Innominate					1	1
Femur			1	1		
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal					1	1
Phalanges	1	1			2	2

AA 8, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			3	1	6	1
Mandible	1	1	1	1	1	1
Tooth	1	1	2	1		
Atlas					2	1
Axis						
Cervical					3	1
Thoracic					3	1
Lumbar					6	1
Sacrum					1	1
Caudal						
Rib					10	2
Sternum						
Scapula						
Humerus					3	1
Radius/Ulna			2	2	4	2
Carpal						
Metacarpal	1	1	2	2		
Innominate	1	1	2	2	6	3
Femur	3	1			5	1
Tibia			1	1	4	1
Fibula						
Astragalus			1	1		
Calcaneus			1	1		
Tarsal						
Metatarsal	2	1	2	1		
Phalanges	4	4	5	4	1	1

AA 8, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges	1	1	1	1		

AA 9, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	5	2	5	1	15	1
Mandible	2	1	5	1	3	1
Tooth	22	3	34	10	2	1
Atlas			2	1	3	1
Axis	1	1			1	1
Cervical					15	5
Thoracic					9	2
Lumbar					10	3
Sacrum					2	1
Caudal						
Rib					20	4
Sternum						
Scapula			1	1	1	1
Humerus	5	2	5	4	5	1
Radius/Ulna	4	2	3	1	7	2
Carpal						
Metacarpal	4	2	4	2	1	1
Innominate	4	3			6	2
Femur	2	2	2	2	6	2
Tibia	6	6	1	1	9	
Fibula						
Astragalus	2	2	1	1	1	1
Calcaneus	3	3	2	2		
Tarsal	2	2	1	1		
Metatarsal	2	1	2	2	2	2
Phalanges	1	1	1	1	2	2

AA 9 Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal			1	1		
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 10, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus			1	1		
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 11, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus					1	1
Tarsal						
Metatarsal						
Phalanges						

AA 11, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 12, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal	1	1				
Phalanges						

AA 13 Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1	3	1
Mandible						
Tooth	1	1	2	2	4	2
Atlas						
Axis						
Cervical					2	1
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					4	1
Sternum						
Scapula			1	1		
Humerus					1	1
Radius/Ulna			1	1	2	2
Carpal			1	1		
Metacarpal			4	2		
Innominate	1	1				
Femur					2	1
Tibia			1	1		
Fibula						
Astragalus			1	1		
Calcaneus			1	1		
Tarsal						
Metatarsal			2	1		
Phalanges	1	1	1	1	2	1

AA 13, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			1	1		
Mandible						
Tooth					2	1
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna			2	1		
Carpal						
Metacarpal			1	1		
Innominate						
Femur					1	1
Tibia			1	1	1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal			1	1		
Metatarsal						
Phalanges					1	1

AA 14, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium			2	1	3	1
Mandible						
Tooth			2	2		
Atlas	1	1				
Axis						
Cervical						
Thoracic					2	2
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal	1	1				
Innominate						
Femur					1	1
Tibia	1	1			2	1
Fibula						
Astragalus			1	1		
Calcaneus	2	2				
Tarsal			1	1		
Metatarsal						
Phalanges	1	1			1	1

AA 16, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate					1	1
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 16, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1				
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					2	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 19, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus						
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 20, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible	1	1				
Tooth			1	1		
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula					1	1
Humerus			3	2		
Radius/Ulna					1	1
Carpal						
Metacarpal			1	1		
Innominate						
Femur					2	2
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal	1	1				
Metatarsal						
Phalanges						

AA 24, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium	1	1	2	1	2	1
Mandible	1	1	1	1		
Tooth	1	1	1	1	3	2
Atlas	1	1				
Axis						
Cervical					1	1
Thoracic						
Lumbar					4	2
Sacrum	1	1			1	1
Caudal						
Rib					19	4
Sternum						
Scapula			1	1		
Humerus					3	2
Radius/Ulna	3	2				
Carpal			7	7		
Metacarpal					1	1
Innominate			1	1	6	2
Femur			1	1	3	2
Tibia	2	2	1	1	5	2
Fibula						
Astragalus	1	1	1	1		
Calcaneus	1	1			1	1
Tarsal	1	1	2	2		
Metatarsal	3	1				
Phalanges	3	3	2	2	2	1

AA 25, Fill

Element	*Odocoileus*		*Ovis*		Artiodactyl	
	NISP	MNE	NISP	MNE	NISP	MNE
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					2	2
Radius/Ulna						
Carpal						
Metacarpal					1	1
Innominate						
Femur			1	1	2	1
Tibia			1	1		
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal			1	1		
Phalanges						

AA 25, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 27, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic					1	1
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					1	1
Radius/Ulna						
Carpal						
Metacarpal			1	1		
Innominate	2	2				
Femur						
Tibia					1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal					1	1
Metatarsal	2	1				
Phalanges						

AA 28, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium	2	1	2	1	1	1
Mandible			1	1		
Tooth	1	1	3		4	2
Atlas					1	1
Axis					1	1
Cervical					2	1
Thoracic					3	1
Lumbar					4	1
Sacrum					1	1
Caudal						
Rib					13	4
Sternum						
Scapula					1	1
Humerus	3	3			7	5
Radius/Ulna			4	2	5	2
Carpal	2	2	1	1		
Metacarpal	1	1	2	1	1	1
Innominate	2	1			3	2
Femur	4	3			3	1
Tibia	1	1	3	2	9	3
Fibula						
Astragalus	3	3	2	2		
Calcaneus	3	3	2	2		
Tarsal	2	2	2	2		
Metatarsal	8	2	2	1	1	1
Phalanges	4	4	10	10	14	8

AA 28, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib						
Sternum						
Scapula						
Humerus	1	1				
Radius/Ulna						
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia						
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges						

AA 29, Floor						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth	1	1	1	1	4	1
Atlas					1	1
Axis						
Cervical					1	1
Thoracic					3	2
Lumbar						
Sacrum					1	1
Caudal						
Rib						
Sternum						
Scapula						
Humerus			3	2	1	1
Radius/Ulna			3	1		
Carpal			1	1		
Metacarpal	1	1	2	1		
Innominate	1	1	1	1	1	1
Femur					1	1
Tibia			2	2	2	2
Fibula						
Astragalus	1	1				
Calcaneus	1	1				
Tarsal						
Metatarsal						
Phalanges			1		2	

AA 30, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth					3	1
Atlas						
Axis						
Cervical						
Thoracic						
Lumbar						
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus					2	2
Radius/Ulna					1	1
Carpal						
Metacarpal						
Innominate						
Femur					1	1
Tibia			2	2	2	2
Fibula						
Astragalus						
Calcaneus			1	1		
Tarsal			1	1		
Metatarsal						
Phalanges					1	1

AA C, Fill						
Element	***Odocoileus***		***Ovis***		**Artiodactyl**	
	NISP	**MNE**	**NISP**	**MNE**	**NISP**	**MNE**
Cranium						
Mandible						
Tooth						
Atlas						
Axis						
Cervical					1	1
Thoracic						
Lumbar					1	1
Sacrum						
Caudal						
Rib					1	1
Sternum						
Scapula						
Humerus	2	2				
Radius/Ulna	1	1				
Carpal						
Metacarpal						
Innominate						
Femur						
Tibia	2	1			1	1
Fibula						
Astragalus						
Calcaneus						
Tarsal						
Metatarsal						
Phalanges					2	2

Appendix C:

STRONTIUM ISOTOPE DATA

Sample	**Distance from Neck (mm)**	**$^{87/86}$Sr**	**error**	**Catalog**	**Provenience**	**Period**	**Taxon**	**Tooth**	**Age**	**Sample Weight (mg)**
8099-M2-1	6.8	0.709293	0.000021	8099-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	18.01
8099-M2-2	11.32	0.70917	0.0000098	8099-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	13.28
8099-M2-3	15.2	0.709365	0.00001	8099-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	19.81
8099-M2-4	19.1	0.709405	0.000015	8099-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	20.74
8099-M2-5	22.35	0.709399	0.000016	8099-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	8.41
8099-M3-1	8.5	0.709408	0.000025	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	17.93
8099-M3-2	12.25	0.708855	0.000021	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	15.97
8099-M3-3	15.9	0.708734	0.000019	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	20.51
8099-M3-4	19.65	0.70855	0.000011	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	21.25
8099-M3-5	24.1	0.708899	0.000019	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	26.78
8099-M3-6	28.42	0.709166	0.000033	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	21.95
8099-M3-7	33	0.70934	0.000029	8099-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	21.88
8099-SED (acetic)		0.709121	0.000011	8099-001	Pithouse 3	2B	--	--	--	713.28
8099-SED (HCl)		0.709085	0.000027							

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8102-M2-1	10.24	0.71008	0.00002	8102-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	18.77
8102-M2-2	13.66	0.71021	0.00003	8102-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	21.65
8102-M2-3	17.75	0.71023	0.00008	8102-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	17.62
8102-M2-4	21.47	0.71042	0.00003	8102-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	19.34
8102-M2-5	25.86	0.71046	0.00003	8102-001	Pithouse 3	2B	*Ovis*	M_2	4 yrs	19.85
8102-M3-1	2.83	0.71081	0.00006	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	10.25
8102-M3-2	7	0.71048	0.00002	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	13.79
8102-M3-3	11.4	0.70992	0.00004	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	16.60
8102-M3-4	15.25	0.71006	0.00001	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	17.94
8102-M3-5	19.38	0.71022	0.00002	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	20.86
8102-M3-6	22.87	0.71039	0.00003	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	19.36
8102-M3-7	26.4	0.71049	0.00002	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	19.04
8102-M3-8	30.18	0.71053	0.00001	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	21.23
8102-M3-9	34.34	0.71050	0.00002	8102-001	Pithouse 3	2B	*Ovis*	M_3	4 yrs	20.95
8102-SED (acetic)		0.70923	0.000025	8102-001	Pithouse 3	2B	--	--	--	557.38
8102-SED (HCl)		0.708847	0.000018							

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8208-M2-1	13.37	0.71023	0.00002	8208-001	Pithouse 29	1	*Ovis*	M_2	3.5 yrs	25.42
8208-M2-2	17.48	0.71050	0.00003	8208-001	Pithouse 29	1	*Ovis*	M_2	3.5 yrs	25.84
8208-M2-3	21.29	0.71043	0.00001	8208-001	Pithouse 29	1	*Ovis*	M_2	3.5 yrs	23.22
8208-M2-4	25	0.71084	0.00003	8208-001	Pithouse 29	1	*Ovis*	M_2	3.5 yrs	23.60
8208-M2-5	28.88	0.71091	0.00004	8208-001	Pithouse 29	1	*Ovis*	M_2	3.5 yrs	22.55
8208-M2-6	32.56	0.71062	0.00001	8208-001	Pithouse 29	1	*Ovis*	M_2	3.5 yrs	22.08
8208-M3-1	10.119	0.71061	0.00001	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	21.06
8208-M3-2	13.61	0.71034	0.00002	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	22.16
8208-M3-3	17.26	0.71054	0.00001	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	22.07
8208-M3-4	21.11	0.71043	0.00001	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	25.12
8208-M3-5	24.98	0.71043	0.00002	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	24.33
8208-M3-6	28.73	0.71029	0.00003	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	22.01
8208-M3-7	32.66	0.71047	0.00002	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	20.76
8208-M3-8	35.57	0.71006	0.00006	8208-001	Pithouse 29	1	*Ovis*	M_3	3.5 yrs	17.52
8208-SED (acetic)		0.709473	0.000013	8208-001	Pithouse 29	1	--	--	--	133.17
8208-SED (HCl)		0.70947	0.000014							

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8220-M2-1	6.95	0.71087	0.00002	8220-001	Pithouse 28	1	*Ovis*	M_2	4+ yrs	21.80
8220-M2-2	10.3	0.71068	0.00003	8220-001	Pithouse 28	1	*Ovis*	M_2	4+ yrs	20.85
8220-M2-3	13.88	0.71058	0.00002	8220-001	Pithouse 28	1	*Ovis*	M_2	4+ yrs	20.34
8220-M2-4	17.24	0.71099	0.00001	8220-001	Pithouse 28	1	*Ovis*	M_2	4+ yrs	16.72
8220-M2-5	20.89	0.71098	0.00001	8220-001	Pithouse 28	1	*Ovis*	M_2	4+ yrs	21.17
8220-M2-6	25.05	0.71093	0.00003	8220-001	Pithouse 28	1	*Ovis*	M_2	4+ yrs	17.93

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8225-M2-1	3.1	~~Sr too low~~	~~Sr too low~~	8225-001	Pithouse 28	1	*Ovis*	M_2	4 yrs	12.75
8225-M2-2	6.87	0.71079	0.00002	8225-001	Pithouse 28	1	*Ovis*	M_2	4 yrs	15.39
8225-M2-3	11.51	0.71066	0.00003	8225-001	Pithouse 28	1	*Ovis*	M_2	4 yrs	20.35
8225-M2-4	14.84	0.71072	0.00004	8225-001	Pithouse 28	1	*Ovis*	M_2	4 yrs	24.24
8225-M2-5	18.42	0.71075	0.00001	8225-001	Pithouse 28	1	*Ovis*	M_2	4 yrs	27.04
8225-M3-1	10.05	0.71079	0.00001	8225-001	Pithouse 28	1	*Ovis*	M_3	4 yrs	26.23
8225-M3-2	14.96	0.71083	0.00002	8225-001	Pithouse 28	1	*Ovis*	M_3	4 yrs	25.62
8225-M3-3	18.66	0.71077	0.00002	8225-001	Pithouse 28	1	*Ovis*	M_3	4 yrs	25.83
8225-M3-4	22.89	0.71082	0.00001	8225-001	Pithouse 28	1	*Ovis*	M_3	4 yrs	27.20

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8265-M2-1	6.96	0.710314	0.00002	8265-001	Pithouse 26	UNK	*Ovis*	M_2	3.5 yrs	20.54
8265-M2-2	10.78	0.710308	0.000026	8265-001	Pithouse 26	UNK	*Ovis*	M_2	3.5 yrs	14.09
8265-M2-3	14.12	0.710315	0.000033	8265-001	Pithouse 26	UNK	*Ovis*	M_2	3.5 yrs	18.27
8265-M2-4	18.54	0.710147	0.000016	8265-001	Pithouse 26	UNK	*Ovis*	M_2	3.5 yrs	21.60
8265-M2-5	22.44	0.710298	0.000044	8265-001	Pithouse 26	UNK	*Ovis*	M_2	3.5 yrs	17.64
8265-M3-1	3.9	0.710396	0.000034	8265-001	Pithouse 26	UNK	*Ovis*	M_3	3.5 yrs	15.27
8265-M3-2	7.45	0.710253	0.000023	8265-001	Pithouse 26	UNK	*Ovis*	M_3	3.5 yrs	15.90
8265-M3-3	12.06	0.710272	0.000022	8265-001	Pithouse 26	UNK	*Ovis*	M_3	3.5 yrs	10.66
8265-M3-4	15.98	0.710332	0.000041	8265-001	Pithouse 26	UNK	*Ovis*	M_3	3.5 yrs	13.99

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8304-M2-1	23.25	0.70856	0.00002	8304-001a	Pithouse 5	2A	*Ovis*	M_2	1 yr	11.22
8304-M2-2	27.22	0.70855	0.00001	8304-001a	Pithouse 5	2A	*Ovis*	M_2	1 yr	19.49
8304-M2-3	31.43	0.70858	0.00002	8304-001a	Pithouse 5	2A	*Ovis*	M_2	1 yr	15.88

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
8644-PM4-1	8.59	0.710143	0.000018	8644-001a	Pithouse 75	2B	*Odocoileus*	PM$_4$	3.5 yrs	17.50
8687-M3-1	4.5	0.710124	0.000027	8687-001b	Pithouse 75	2B	*Odocoileus*	M$_3$	3.5 yrs	14.00
8687-M3-2	7.63	0.710427	0.000023	8687-001b	Pithouse 75	2B	*Odocoileus*	M$_3$	3.5 yrs	17.21

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
9948-M3-1	3.24	0.710436	0.000015	9948-009b	Pithouse 61	2A	*Odocoileus*	M^3	2+ yrs	17.00
9948-M3-2	6.8	0.710419	0.000028	9948-009b	Pithouse 61	2A	*Odocoileus*	M^3	2+ yrs	19.54

Sample	Distance from Neck (mm)	$^{87/86}$Sr	error	Catalog	Provenience	Period	Taxon	Tooth	Age	Sample Weight (mg)
10046-PM4-1	9.12	0.710735	0.000015	10046-002	Pithouse 62	2B	*Odocoileus*	PM$_4$	2+	38.47

Sample	**Distance from Neck (mm)**	**$^{87/86}$Sr**	**error**	**Catalog**	**Provenience**	**Period**	**Taxon**	**Tooth**	**Age**	**Sample Weight (mg)**
10249-M2-1	2.68	0.70798	0.00002	10249-023	Activity Area 24	2A	*Ovis*	M_2	> 5 yrs	16.61
10249-M2-2	6.09	0.70836	0.00002	10249-023	Activity Area 24	2A	*Ovis*	M_2	> 5 yrs	17.12
10249-M2-3	9.33	0.708445	0.00002	10249-023	Activity Area 24	2A	*Ovis*	M_2	> 5 yrs	15.96
10249-M3-1	5.31	0.709479	0.000017	10249-023	Activity Area 24	2A	*Ovis*	M_3	> 5 yrs	23.99
10249-M3-2	9.5	0.709638	0.000021	10249-023	Activity Area 24	2A	*Ovis*	M_3	> 5 yrs	27.26
10249-M3-3	12.84	0.708528	0.000012	10249-023	Activity Area 24	2A	*Ovis*	M_3	> 5 yrs	22.14
10249-M3-4	16.19	0.708241	0.000018	10249-023	Activity Area 24	2A	*Ovis*	M_3	> 5 yrs	22.17
10249-M3-5	18.46	0.708319	0.000013	10249-023	Activity Area 24	2A	*Ovis*	M_3	> 5 yrs	36.86
10249-M3-6	22	0.707999	0.000016	10249-023	Activity Area 24	2A	*Ovis*	M_3	> 5 yrs	47.85
10249-SED (acetic)		0.708509	0.000022	10249-023	Activity Area 24	2A	--	--	--	210.03
10249-SED (HCl)		0.708256	0.000016	10249-023	Activity Area 24	2A	--	--	--	210.03

CURRICULUM VITAE
Jacob L Fisher

REVISED: September 6, 2010

Education:

University of Washington, Ph.D. in Anthropology, 2010

Dissertation: *Costly Signaling and Changing Faunal Abundances at Five Finger Ridge, Utah*

University of Washington, M.A. in Anthropology, 2004

University of California-Santa Cruz, B.A. in Anthropology, 2000

Current Position:

Assistant Professor & NAGPRA Director, Department of Anthropology, California State University, Sacramento, August 2010 - present

Previous Teaching Experience (Teaching Portfolio available upon request):

Workshop Facilitator for Teaching Assistant Conference, UW; Fall 2009

Instructor for Archaeological Lab Techniques, UW; Spring 2009

Teaching Assistant for Evolution and Human Behavior, UW; Spring 2009

Reader for Principles of Archaeology, UW; Winter 2009

Teaching Assistant for Human Biological Diversity, UW; Fall 2008, Fall 2007

Instructor for New World Archaeology, UW; Spring 2008, Summer 2006, Winter 2006

Teaching Assistant for Analysis of Faunal Remains (ARCHY 481), UW, Spring 2007

Teaching Assistant for Principles of Archaeology, UW; Winter 2007, Fall 2005

Teaching Assistant for Introduction to Anthropology, UW; Fall 2006

Tutor for Principles of Archaeology, Center for Learning and Undergraduate Enrichment, UW; Fall 2006

Teaching Assistant for Analysis of Stone Artifacts, UW; Fall 2004

Archaeology Summer Camp Instructor, Burke Museum; Summer 2003

Course Assistant for Introduction to Archaeology, UCSC; Spring 2002, Spring 2001

Research and Field Employment:

Archaeology Lab and Resources Manager, UW; 2009-10

Undergraduate Admissions Review Reader, UW; Winter 2009, Winter 2008

Archaeology Public Outreach Program Coordinator, Burke Museum; Spring 2006, Winter 2003

NAGPRA Coordinator Assistant, Burke Museum; Spring 2005

NAGPRA GIS Project Technician, Burke Museum; 2004-05

Anthropogenic Prairies Project Researcher, UW; Summer-Fall 2003

NAGPRA Coordinator Assistant, Burke Museum; Spring 2003

Archaeologist, Pacific Legacy, Inc. (Santa Cruz, CA); 2000-02, 2005-08 (intermittent)

Archaeologist, AMEC (Redmond, WA); Summer 2006

Archaeologist, BOAS, Inc., (Seattle, WA); Summer 2006, Summer 2005

Awards and Distinctions:

Letter for Excellence in Teaching, Dean of Arts and Sciences, University of Washington, 2007

Peggy Yeager Award for Teaching Excellence in Archaeology, University of Washington, 2007

Baby Niles Fellowship, Department of Anthropology, University of Washington, 2002

Thesis Honors, Department Honors, College Honors, University of California-Santa Cruz, 2000

Fellowships and Grants:

Student Technology Fee Grant, 2010, Rugged Mobile Computing Systems for Archaeological Fieldwork ($32,577).

Wenner-Gren Dissertation Fieldwork Grant, 2008-2010, Costly Signaling in the Archaeological Record: A Case Study from Western North America ($15,700)

National Science Foundation Dissertation Improvement Grant, 2008-2010, Costly Signaling in the Archaeological Record: A Case Study from Western North America ($14,964)

Quaternary Research Center Pilot Research Funds (University of Washington), 2007 ($2000)

National Park Service NAGPRA Museum Documentation Grant, 2003, Museum and Tribal GIS Database Development and Training (with J. Nason, P. Lape, L. Phillips, and M. Noble) ($140,021)

Professional Societies:

Society for American Archaeology, 2002-present

Society for California Archaeology, 1999-present

International Council of Archaeozoology, 2004-present

Research Interests:

Theoretical/Conceptual: Human Behavioral Ecology, Culinary Processing, Paleoecology, Conservation Biology, Native American-Archaeologist Relationships
Methods: Zooarchaeology, Stable Isotope Analysis
Regional: North American Prehistory, esp. California, Great Basin, and adjacent regions

Archaeological Field Experience:

2009	Test excavations at University of Washington Greenhouse, Seattle, WA (UW)
2008	Survey, Washoe & Humboldt Co., Nevada (Pacific Legacy)
2007	Data recovery excavation, St. Helena, Napa Co, CA (Pacific Legacy)

2006	Test excavations, Redmond, King Co., WA (AMEC)
2006	Test Excavations, Granite Falls, Snohomish Co., WA (BOAS)
2006	Survey, Vashon Island, King Co., WA (Burke Museum)
2005	Survey, Big Creek Drainage, southern Sierra Nevada, CA (Pacific Legacy)
2005	Survey & test excavations, Carnation, King County, WA (BOAS).
2004	Data recovery excavations, Watmough Bay, Lopez Island, WA (UW)
2004	Survey, Trump Island, Island Co., WA (UW)
2004	Geoarchaeological Excavations, Port Orchard, Kitsap Co., WA (UW)
2004	Geoarchaeological Excavations, Cattle Point, San Juan Island, WA (UW)
2003	Data recovery excavations, Ebey's Landing, Whidbey Ilsand, WA (NPS)
2002	Survey, Los Banos, northern San Joaquin Valley, CA (Pacific Legacy)
2002	Data recovery excavations, Elk Hills, southern San Joaquin Valley, CA (Pacific Legacy)
2002	Survey, Jose Basin, southern Sierra Nevada, CA (Pacific Legacy)
2001	Data recovery excavations, Red Bluff, Tehama Co, CA (Pacific Legacy)
2001	Test excavations, Hayfork, Trinity Co., CA (Pacific Legacy)
2001	Test excavations, Poison Lake, Lassen Co., CA (Pacific Legacy)
2001	Survey, Sacramento Delta, CA (Pacific Legacy)
2001	Test excavations, Clear Lake, Lake Co., CA (Pacific Legacy)
2001	Data recovery excavations, Moss Landing, Monterey Co., CA (Pacific Legacy)
2000	Survey, Springville, southern Sierra Nevada, CA (Pacific Legacy)
2000	Data recovery excavations, Watsonville, Santa Cruz Co., CA (Pacific Legacy)
2000	Test and Data recovery excavations, Clear Lake, Lake Co., CA (Pacific Legacy)
2000	Data recovery excavations, Palo Alto, Santa Clara Co., CA (Pacific Legacy)
1999	Research excavations, Peetz (High Plains), Logan Co., Colorado (U. of Wyoming)
1999	Field school excavation, San Francisco Presidio, SF Co., CA (Cabrillo College)
1999	Field school survey, Los Padres Nat'l Forest, Central Coast Ranges, CA (Cabrillo College)

Faunal Analysis Experience

2008-10	Analysis of fauna from Five Finger Ridge, Fremont Period, central Utah.
2010	Stable isotope (Sr, O, C) analysis of artiodactyls from Five Finger Ridge, Fremont Period, central Utah
2006-2008	Analysis of fauna from Antelope Cave, late Basketmaker – Early Puebloan, northwestern Arizona
2005	Analysis of fauna from North Creek Shelter, Escalante Valley, southern Utah (with M. Herkelrath and R. Kessler)
2000	Analysis of fauna from Pa'ako Pueblo, New Mexico (under D. Gifford-Gonzalez)

1999 Analysis of fauna from Donovan Bison Processing Site, northwestern Colorado (under L. Schreiber)

Publications & Reports:

Fisher, J.L. and Keith L. Johnson
In review. Culinary Processing of Jackrabbits at Antelope Cave, Arizona. Submitted to *Journal of Anthropological Archaeology* (May 20, 2010)

Fisher, J.L.
2009 Unmodified Faunal Remains from Antelope Cave, Arizona. Prepared for Keith Johnson, Chico State University.

Grayson, D.K. and **J.L. Fisher**
2009 Holocene Elk (*Cervus elaphus*) in the Great Basin. In, *Past, Present, and Future Issues in Great Basin Archaeology*, Cuttural Resource Series 20, edited by B.S. Hockett. Bureau of Land Management.

Stein, J., S. Anderson and **J.L. Fisher**
2006 *Report on the Ebey's Prairie Depositional History. Submitted in partial fulfillment of CESU contract "Native Americans and the Pacific Northwest Environment: An Interdisciplinary Study"*. University of Washington.

Fisher, J. L., M. Herkelrath, R. Kessler and D. K. Grayson
2005 Report on the Fauna Assemblage at North Creek Shelter, Utah. Prepared for Joel Janetski at Brigham Young University.

Fisher, J.L.
2002 Lithic Analysis. In *Archaeological Data Recovery Excavations at CA-MNT-229 for Proposed Roadway Improvements at State Route 1 and Dolan Road, Moss Landing, Monterey County, California (SR1/Dolan Road, K.P. 154.66; M.P. 96.10). On file, Central Coast Information Center. [Prepared for California Department of Transportation, District 5, San Luis Obispo, CA].* edited by R. Gargett and T. L. Jackson.

Jackson, T.L., **J.L. Fisher** and B. Culleton
2002 Archaeological Data Recovery at CA-KER-3079 for Occidental Petroleum SOZ Well 33-25S. On file, Southern San Joaquin Valley Information Center, California State University, Bakersfield. [Prepared for ICF Consulting, Fairfax, VA].

Fisher, J.L.
2001 Lithic Analysis. In *Archaeological Inventory and Excavation at Five Sites on the Handley Ranch , Near Gonzalez, Monterey County, California: CA-MNT-2053 (P-27-002390),CA-MNT-2054H (P-27-002391),CA-MNT-2055H (P-27-002392),CA-MNT-2056H (P-27-002393),CA-MNT-2057H (P-27-002394),CA-MNT-2049 (P-27-002389). On file, Information Center. [Prepared for Granite Construction Inc., Watsonville, CA].* edited by R. Gargett, B. Culleton and T. L. Jackson

Paper Presentations:

2011 Paper to be presented at the 76th Annual Meeting of the Society for American Archaeology, Sacramento, CA (abstract submitted)

2010 Fauna, Isotopes, and Climate Change at Five Finger Ridge, Utah. Paper presented at the Great Basin Anthropology Conference, Layton, UT. (abstract accepted)

2010 Processing and Consumption of Jackrabbits at Antelope Cave, AZ. Paper presented at the 75th Annual Meeting of the Society for American Archaeology, St. Louis, MO.

2007 Western Pond Turtle (*Actinemys marmorata*): Archaeology and Biogeography in the

Puget Sound region. Poster presented at the 72nd Annual Meeting of the Society for American Archaeology, Austin.

2005 Paleoarchaic Occupations in the GSENM: Data from North Creek Shelter (with J. Janestski, R. A. Kessler, M. Herkelrath, and D. K. Grayson.

Invited Speaker:

2010 Butchering Bunches of Bunnies (Every Hare Counts): Processing and Consumption of Jackrabbits at Antelope Cave, AZ. Invited speaker to Department of Anthropology, Portland State University.

Committee Memberships:

2010-Present	Collections Committee, Chair (CSUS Anthropology)
2010-Present	NAGPRA Advisory Committee (CSUS Social Sciences & Interdisciplinary Studies)
2010-Present	NAGPRA Tribal Committee (CSUS-wide)
2008-2009	Breadth in Anthropological Research Conference Committee (Anthropology, UW)
2007-2008	Breadth in Anthropological Research Conference Committee (Anthropology, UW)
2007-2008	Graduate Student Activities Funds Committee (Department of Anthropology, UW)
2006-2007	Teaching Effectiveness Committee (Department of Anthropology, UW)
2005-2006	Sub-faculty Appointments Committee (Department of Anthropology, UW)
2005	Search Committee for professor/curator (Department of Anthropology, UW)
2004-2005	Graduate Student Activities Funds Committee (Department of Anthropology, UW)
2003-2004	Curriculum Committee (Department of Anthropology, UW)