Prehistoric Diet at Bonneville Estates Rockshelter, Nevada

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By

Cassandra J. Albush

Dr. Donald L. Hardesty/Thesis Advisor

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We recommend that the thesis prepared under our supervision by

CASSANDRA JEAN ALBUSH

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Donald L. Hardesty, Ph.D, Advisor

David E. Rhode, Ph.D., Committee Member

Nancy L. Markee, Graduate School Representative

Marsha H. Read, Ph. D., Associate Dean, Graduate School

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Abstract

Issues of subsistence and settlement patterns have long been a central focus of archaeological research within the Great Basin. Coprolites, which are common in the Great Basin’s archaeological caves and rockshelters, provide the most direct evidence of subsistence activities of prehistoric hunter-gatherer groups. Coprolite analysis, however, is not without its limitations and combining coprolite data with faunal and botanical data from an archaeological site can provide a clearer picture of the complete diet of a prehistoric population. This thesis presents data from the analysis of 18 coprolites from the Bonneville Estates Rockshelter in eastern Nevada and integrates it with existing data of the faunal and botanical assemblages from the site. Models of Optimal Foraging Theory are used to provide a framework to explain variability and change in the archaeological record.
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Chapter 1: Introduction

Issues of subsistence and settlement patterns have long been a central focus of archaeological research within the Great Basin. According to Zeanah and Simms:

Issues of subsistence and settlement [are] central to Great Basin archaeology, not because these are the only kinds of data available in the region, or because foraging bands are somehow more understandable from a materialist perspective than are complex societies. Subsistence-settlement issues [are] essential because without sophisticated modeling of infrastructure, perceptions of social structure and ideology lack an explanatory base [1999:135-136].

Julian Steward was one of the first Great Basinists to address the relationship between subsistence-settlement patterns and the social organization of native Great Basin groups. In Basin-Plateau Aboriginal Sociopolitical Groups (1938) Steward’s ethnographic work with 40 native Indian groups within the Great Basin led to the formulation of an over-arching framework of cultural evolution that he termed “Cultural Ecology.” Cultural Ecology attempted to explain subsistence-settlement patterns as the result of the interaction between culture and the environment (Steward 1938, 1955). Steward saw the relationship between humans and their environment as a creative process that involved two independent variables; environment and the “cultural core — the constellation of features which are most closely related to subsistence activities and economic arrangements. The core includes such social, political, and religious patterns as are empirically determined to be closely connected with these arrangements” (1955:37; emphasis in original). Steward states that:
Any adaptation necessarily involves the interaction of two elements: The
natural environment and the particular cultural devices invented and
borrowed, by which the environment is exploited… The present problem,
therefore, is partly to ascertain the effect of ecology upon the
sociopolitical institutions… Analysis of human ecology in the Basin
Plateau area requires consideration first of certain features of the natural
landscape or environment; second, of cultural devices by which the
environment was exploited; and third of resulting adaptation of human
behavior and institutions [1938:2].

In the 1950s Jesse Jennings applied Steward’s ethnography of modern Great
Basin tribes to the archaeological record of the region. The result was the formulation of
the Desert Culture or Desert Archaic model in which the adaptations of prehistoric
groups were interpreted within the context of ethnographically known patterns (Jennings
1957; Jennings and Norbeck 1955). Based on excavations conducted at Danger Cave in
the Eastern Great Basin, Jennings stated that:

Certainly a desert way of life fundamentally like that of historic times was
established early… For nearly 10 millennia the same general pattern of
life is followed, a nomadic wandering from valley to upland, to take best
advantage of the resources of nature… As the climate varied, man appears
to have continued life with little change by means of adjustment to
different altitudes [Jennings and Norbeck 1957:3].

Almost as soon as it was published, the Desert Culture model encountered
criticism from Great Basin archaeologists and cultural anthropologists (see Beck 1999;
Bettinger 1998; Fowler and Jennings 1982; O’Connell and Madsen 1982; Madsen 1982; and Rhode 1999 for a full discussion of the controversy over the Desert Culture model. One of the major criticisms of the model was its assumption of Basin-wide cultural patterns. As several critics have pointed out (Bettinger 1977, 1993, 1998; Madsen 1982; Madsen and Berry 1975), the Great Basin is not a homogeneous region and a wide range of variability is seen in both the ethnographic and archaeological record.

In order to deal with this variability, Great Basin archaeologists during the 1980s began to turn towards Evolutionary Ecology as an explanatory framework capable of providing testable models of variability and change in the archaeological record (Bettinger and Baumhoff 1982; O’Connell et al. 1982). Evolutionary Ecology is similar to Cultural Ecology in that it looks at the interaction between organisms and their environment. Unlike Cultural Ecology however, Evolutionary Ecology provides models in which to test variability and change. Evolutionary ecological models are an import to anthropology from evolutionary biology and micro-economics (Bettinger 1991; Kelly 1995; Madsen and Schmitt 1998; Winterhalder 2001). Grouped under the umbrella of Optimal Foraging Theory, these models are concerned with the “why” of decision making in human foraging groups (i.e., why does a foraging group exploit some resources and not others?). Optimal Foraging Theory moves beyond Cultural Ecology which “is ultimately unable to explain why man-environment relationships take the form they do, and thus it cannot contribute to the comprehensive reconstruction of behavioral systems that are unlike those known ethnographically” (O’Connell et al. 1982:227).

The central hypothesis of Optimal Foraging Theory is that foragers will always forage in a manner that optimizes their net return rate of energy (calories harvested per
In order to build models to test variability and change in prehistoric subsistence strategies it is necessary to first know which food resources provide the greatest gain in energy, and a great deal of work in the Great Basin has focused on deriving experimental return rates for many of the food resources known to be utilized both in ethnographic and prehistoric times (see Barlow and Metcalfe 1996; Jones and Madsen 1989; Madsen and Schmitt 1998; Simms 1987). To test these models, however, we need subsistence data from archaeological sites.

There are three types of archaeological data that are used to reconstruct subsistence: animal remains (faunal), plant remains (botanical), and human fecal matter (coprolites). Because animal and plant remains are commonly incorporated into archaeological sites through non-cultural means (e.g., wind, burrowing animals, carnivores) it is difficult to recreate subsistence from these types of data alone. The most direct evidence of subsistence is coprolites which contain the remnants of ingested food items. This type of subsistence data is of even greater interpretive value when combined with faunal and botanical data (Reinhard and Bryant 1992:269). Coprolites are common in the Great Basin’s archaeological caves and rockshelters, and have often been analyzed to reconstruct subsistence of the region’s prehistoric hunter-gatherer groups (Fry 1976, 1980; Heizer and Napton 1969; Jennings 1957; Rhode 2003). Recently a rockshelter was discovered in the eastern Great Basin that contains evidence for human occupation spanning the late Pleistocene to the late Holocene. A well stratified site, Bonneville Estates Rockshelter has yielded a large collection of human coprolites and provides an excellent case site to test models of Optimal Foraging Theory against the archaeological record.
This thesis has three goals: 1) to present data obtained from an analysis of middle and late Holocene human coprolites from Bonneville Estates Rockshelter, 2) to integrate the coprolite data with data from the faunal and botanical record of Bonneville Estates Rockshelter to interpret the subsistence of the prehistoric occupants, and 3) to examine the subsistence patterns seen at Bonneville Estates Rockshelter within the framework of Optimal Foraging Theory models to determine if the middle and late Holocene occupants were optimal foragers.

**Coprolite Analysis**

Coprolites are mineralized or desiccated feces. The term coprolite comes from the Greek *kopros* meaning dung and *lithos* meaning stone (Merriam-Webster 1993). Coprolites typically come in three forms: (1) the intestinal contents of mummified bodies, (2) fecal material excreted by a single individual, and (3) the disaggregated fecal material that is recovered from latrines and privies (Sutton 1998:87). Contained within a coprolite are the undigested remnants of the last few meals consumed prior to defecation. Pollen, plants, bone, insects, shell, hair, and DNA have all been extracted from coprolites and have been analyzed in order to reconstruct the diet of the individual that produced the specimen (Callen 1963; Fry 1976; Heizer 1970; Jenkins 2007; Martin and Sharrock 1964; Minnis 1989; Rhode 2003; Sobolik 1993; Sutton 1998; Sutton and Reinhard 1995; Poinar et al. 1998).

The analysis of coprolites has a distinct advantage over other types of subsistence data analysis (e.g., faunal and botanical assemblages) in that it can be safely assumed that the majority of constituents found within coprolites were intentionally ingested (Sutton
Furthermore, it can be assumed that coprolite constituents are primarily of dietary origin (Reinhard and Bryant 1992). Because the origin of faunal and botanical remains from archaeological sites is often not well enough understood, it cannot be assumed that: 1) humans were the primary agent in their creation, or 2) that the faunal or botanical remains are a result of subsistence activities and not other activities such as tool making, shelter, clothing, and bedding (Rhode and Louderback 2007; Sobolik 1993; Sutton 1998; Sutton and Reinhard 1995).

The analysis of human coprolites from archaeological contexts can be used to address several questions that are important to the study of how prehistoric people lived including: diet, nutrition, health, disease, pharmacology, resource utilization, ecological adaptation, behavior (e.g., status, ceremony, food processing and preparation technology), and culture change (Fry 1976; Minnis 1989; Reinhard and Bryant 1992; Rhode 2003; Sobolik 1990; Sutton 1998; Sutton and Reinhard 1995).

Coprolite data is particularly amenable to studying dietary breadth and subsistence-settlement strategies. For example Rhode (2003) analyzed coprolites from two distinct occupational layers at Hidden Cave to address issues of diet, gender, and mobility in the Carson Sink area. Coprolite constituents from both occupations demonstrated a focus on wetland resources such as cattail, fish, and waterfowl. Decrease in the frequency of certain resources such as cattail pollen and a corresponding increase in the number of seed taxa resulting in a broader diet breadth during the latter occupation layer was interpreted as a decrease in focus on high-ranking wetland resources. Although detailed paleoclimatic data are not available for the Carson Sink, the coprolite data suggests that wetlands may have been located farther away from Hidden Cave during the
later occupation resulting in higher transport costs for wetland resources and consequently the inclusion of lower-ranked, but closer desert resources into the diet (Rhode 2003:919). Hormone testing of the fecal specimens determined that only females likely used the cave indicating some gender-based differences in foraging strategies such as may be expected if the prehistoric occupants of the Carson Sink area employed a Central Place Foraging subsistence-settlement strategy.

Coprological analysis, however, is not without its limitations. Because coprolites contain the undigested remnants of food items they can be used to identify dietary items; however, they cannot necessarily be used to reconstruct dietary composition (Fry 1976, 1985; Minnis 1989; Reinhard and Bryant 1992; Sobolik 1990). For example, certain food items such as seeds, bone, feathers, hair, shell, and insects pass through the digestive system nearly unchanged while other items such as animal flesh and plant parts other than seeds (e.g., flowers, leaves, roots, bark, and tubers) are often completely digested or otherwise recognizable only as unidentifiable crushed plant or animal fibers (Fry 1976, 1985; Sobolik 1990). The result is that coprological constituents do not necessarily reflect all dietary items or their relative importance to the diet. For instance, the consumption of large animal meat is often underrepresented in coprolites. This is because soft animal tissue is almost entirely digested and bones from large animals are not intentionally ingested (although some small fragments may be accidentally ingested).

Combining coprological data with faunal and botanical data from an archaeological site can provide a clearer picture of the complete diet of a prehistoric population (Reinhard and Bryant 1992:269). The analysis of faunal and botanical remains may indicate items that were consumed but are no longer identifiable once they have passed
through the human digestive system, and the presence of botanical and faunal remains within coprolites can confirm that they were consumed as part of the diet.

Both faunal and botanical data have been analyzed from Bonneville Estates Rockshelter by others (Baker 2006; Hockett 2007; Rhode 2006; Rhode and Louderback 2007). The coprolite data will be integrated with the faunal and botanical data in order to gain a better understanding of prehistoric subsistence-settlement strategies of the Bonneville Estates Rockshelter occupants.

**Optimal Foraging Theory**

Anthropologists commonly employ three models of Optimal Foraging Theory to predict how decisions are made by human foragers: the Diet Breadth Model, the Patch Choice Model, and the Central Place Foraging Model. The following sections will describe each of these three models as they have been applied to human foraging societies.

*Diet Breadth Model*

Human foragers face an array of prey items within their environment that vary in terms of their: 1) abundance, 2) the energy benefit to the forager from consumption of that prey item, and 3) the amount of energy the forager needs to expend to extract the energy from the prey item (Bettinger 1991:84). The Diet Breadth Model is used to predict which prey types, when encountered, will be pursued and included in the diet (Bettinger 1991; Kelly 1995; Winterhalder 2001).

In the Diet Breadth Model prey items are ranked according to their net return rate. That is, the item is ranked based on the amount of energy (usually calculated in number
of calories) gained minus the energy costs (time spent processing a resource) of procuring that item (Bettinger 1991; Kelly 1995; Winterhalder 2001). It assumes that foragers will attempt to maximize the amount of calories harvested per unit of time spent foraging and will therefore always pursue the highest ranked prey items. Depending on the abundance of higher ranked prey within the foraging environment, additional prey will be added to the diet in descending order of their rank until the optimal diet breadth has been reached.

A graphical representation of the Diet Breadth Model can be found in Figure 1.1.

Figure 1.1. Graphical Representation of Diet Breadth Model (Bettinger 1991:88)
Bettinger (1991:86-87) uses the following mathematical equation to determine at which point optimality within the diet has been reached:

\[
e_{ix}/t_{x} > \sum_{\text{diet}} p_{i} e_{i} - C_{s} T_{s} / \sum_{\text{diet}} p_{i} t_{i} + T_{s}
\]

The quantity to the left of the inequality is the rate of energy return for a food type being considered for inclusion in the diet where

- \(e_{x}\) is its net energetic yield
- \(t_{x}\) is the amount of time needed to extract that energy, often termed *handling time*

The quantity to the right of the inequality is the rate of energy return for a diet that includes all food types with higher rates of return than the one to the left of the inequality where

- \(p_{i}\) is the proportion of the \(i\)th food type in the environment
- \(e_{i}\) is the usable energetic yield per item of the \(i\)th food type
- \(t_{i}\) is the time expended per item in extracting energy from the \(i\)th food type, that is, per item handling time

- \(C_{s}\) is energetic cost per unit of time expended in searching all items up to and including the \(i\)th food type
- \(T_{s}\) is the time expended in searching for all items up to and including the \(i\)th food type

Prey items will continue to be added to the diet in decreasing order of rank as long as the above inequality favors the item that is included. If, however, an item is added to
the diet that reverses the inequality, the diet should exclude that item and all other lower
ranked resources (Bettinger 1991).

Three important predictions stem from the Diet Breadth Model: 1) high ranked
food items will always be pursued when encountered, 2) as the encounter rate of higher
ranked prey items decreases, lower ranked items will be added to the diet in decreasing
order of rank thereby increasing the diet breadth, and 3) the encounter rate of lower
ranked prey is not a factor in determining inclusion within the diet (Bettinger 1991; Kelly

According to Kelly (1995:88) “the diet-breadth model appears to be sufficiently
simple and general to be a powerful explanatory model,” but as Kelly (1995) and others
(Bettinger 1991; Elston and Zeanah 2002; Madsen and Schmitt 1998; Winterhalder 1986)
point out it is not without its limitations. The Diet Breadth Model makes two
assumptions that are usually not met within the real world of human foragers: 1) it
assumes that resources are homogenously distributed within the environment and will be
encountered in proportion to their abundance and 2) foragers search their environment
without prior knowledge and at random (Kelly 1995). To address these deficiencies in
the Diet Breadth Model, behavioral ecologists employ the Patch Choice and Central
Place Foraging models.

Patch Choice Model

The Patch Choice Model is similar to the Diet Breadth Model, so much so that
Bettinger (1991) considers the Patch Choice Model to be a special case of the Diet
Breadth Model. The Patch Choice Model assumes that resources are not evenly
distributed in the environment but rather occur in patches. The patches are treated as if
they, and all of the resources they contain, are single prey items. This allows patches to be ranked in the same way that prey items are ranked in the Diet Breadth Model. To predict which patches will be included in the foraging itinerary, Bettinger (1991:89) employs a mathematical equation similar to that used for the Diet Breadth Model:

\[ \frac{e_i}{t_x} > \sum_{\text{diet}} p_i e_i - C_s T_s / \sum_{\text{diet}} p_i t_i + T_s \]

The quantity to the left of the inequality is the rate of energy return for patch type being considered for inclusion in the foraging itinerary where

- \( e_x \) is its net energetic yield
- \( t_x \) is the amount of search and pursuit/processing time needed to extract that energy

The quantity to the right of the inequality is the rate of energy return for the foraging itinerary that includes all patch types with higher rates of return than the one to the left of the inequality where

- \( p_i \) is the proportion of the \( i \)th patch type in the environment
- \( e_i \) is the usable energetic yield per patch of the \( i \)th patch type
- \( t_i \) is the time per item expended foraging (searching and pursuing prey) in the \( i \)th patch type
- \( C_s \) is energetic cost per unit of time expended in foraging in all patches up to and including the \( i \)th patch type
- \( T_s \) is the time expended in traveling between patches of all types up to and including the \( i \)th type

While the Patch Choice Model is similar the Diet Breadth Model in many respects, it also differs in that the time spent searching within a patch is included in the
calculation of the net return rate for the patch (Kelly 1995:91). The implication is that more densely populated patches will provide higher net return rates. Whereas the Diet Breadth Model ranks resources according to their net return rate based on an individual encounter rate, the Patch Choice Model ranks resources according to their net return rate based on a mass encounter rate. The consequence is that within the Patch Choice Model resource rankings are more fluid than they are within the Diet Breadth Model. In the Diet Breadth Model the relative abundance of low-ranked resources has no effect on their ranking while the Patch Choice Model allows previously low-ranked resources to become high-ranked resources if their abundance (and therefore encounter rate) becomes sufficiently high that the net return rate for exploiting the resource becomes greater than that of the surrounding environment or that of pursuing another resource (Madsen and Schmitt 1998).

Madsen and Schmitt (1998) illustrate this point when exploring the occurrence of mass collecting events of grasshoppers at Lakeside Cave located in the eastern Great Basin. When collected individually insects are very low-ranked resources and should almost never enter the diet. However, when collected en masse in a “patch” the net return rate of grasshoppers increases as does their ranking.

To determine when a forager should leave a patch for another, anthropologists employ the Marginal Value Theorem (Charnov 1976). The Marginal Value Theorem predicts that foragers will not leave a patch when its net return rate is zero, but rather when the net return rate of the patch falls below the average net return rate for the environment as a whole (Kelly 1995:91). A graphical representation of the Marginal Value Theorem can be found in Figure 1.2.
An important implication of the Marginal Value Theorem is that the more evenly distributed and resource rich the patches are within the environment the less time foragers will spend in each patch. This results because the net return rate of a single patch will quickly fall below that of the environment as a whole. Conversely, foragers will spend more time in each patch in environments where patches are less evenly distributed and/or resource poor because each patch can be exploited longer without dropping below the average net return rate for the environment as a whole. Consequently, when patches are
less evenly distributed in the environment and/or they are of poor quality, intensification of subsistence strategies should occur (Bettinger 1991; Winterhalder 2001).

**Central Place Foraging Model**

Both the Diet Breadth Model and the Patch Choice Model attempt to explain how foragers make decisions about what prey items (or prey patches) will be taken when they are encountered. The Central Place Foraging Model adds a new dimension to these equations by stating that foragers, armed with knowledge of their environment, will travel from a central location (a base camp which is usually situated near a few key resources) to specialized activity areas where resources are acquired and brought back to the base camp (Bettinger 1991; Winterhalder 2001). One of the more interesting aspects of the Central Place Foraging Model is that it emphasizes gender specific subsistence strategies (Elston and Zeanah 2002).

Ranking of prey types is similar to that of the Diet Breadth Model. The ranking of prey types, however, within Central Place Foraging takes into account both travel and handling costs whereas ranking in the Diet Breadth Model takes into account only handling costs (Bettinger 1991). The implication is that when travel times are low, handling costs are more important in determining prey ranking; while conversely, when travel times are high, handling costs become an almost insignificant factor (Bettinger 1999).

Within the Central Place Foraging Model transport costs become an important factor in determining which resources will be included within the diet (Jones and Madsen 1989; Rhode 1990). Jones and Madsen (1989) developed a model for calculating the cost of resource transportation for several important and commonly used Great Basin
resources. Assuming that foragers would not transport resources beyond their maximum transport distance (the point at which the energy expended procuring a resource is equal to the energy gained from exploiting the resource), Jones and Madsen (1989) argue that when resources are transported back to a central base camp several variables such as volume, weight, and distance affect the ranking of resources regardless of their initial net return rate. As an example they illustrate the case of grasshoppers which, when collected en masse, give an initial net return rate of 272,649 calories per hour but when transport costs are included drop to 34,392 calories per basket load (Jones and Madsen 1989:530). On the other hand tansy mustard seeds which have a much lower initial net return rate of 1,307 calories per hour yield an astonishing 132,233 calories per basket load (Jones and Madsen 1989:530). The result is that grasshoppers are more profitable to exploit when they are close to camp whereas tansy mustard seeds may be exploited profitably at far greater distances.

Rhode (1990) further expanded on the Jones-Madsen model and suggested that the costs associated with group mobility and the nature of locally available resources were additional factors in determining how far a resource could be profitably transported. The Jones-Madsen model assumes that transport costs are taken on at the individual level; however, ethnographic accounts of Great Basin groups indicate that foraging was a group effort. Rhode (1990) argues that the costs associated with group mobility are exponentially higher than the costs associated with the mobility of a single individual therefore transport costs would increase in the case of group foraging. Rhode (1990) also points out that the more profitable the locally available resource is, the less profitable extra-local resources become. The additional constraints of group mobility and local
resource availability implies that groups employing a Central Place Foraging strategy may select base camps based on the relative transportability of multiple resources (Rhode 1990:417).

Barlow and Metcalfe (1996) add an additional dimension to transport costs, that of field processing. Using experimental data from two important Great Basin staples, pickleweed and pinyon, Barlow and Metcalfe (1996) demonstrate that field processing of resources can greatly affect their transportability. Their findings indicate that the transport costs of both resources can be decreased with minimal field processing (in the case of pickleweed stripping the seeds from the branches and in the case of pinyon removing the nuts from the cone). Further field processing results in increasingly lower returns and in both cases even short travel times significantly decreases the net return rate of the resource.

As was the case with the Patch Choice Model, the Central Place Foraging Model also predicts when groups should move. Winterhalder (2001:21) states that “camps will move more frequently if (1) relocation costs are low, (2) depletion (or depression) of zones immediately around the occupied camp is rapid, and/or (3) alternative residential sites offer high initial rates of return.”

**Thesis Outline**

The remainder of this thesis is broken down into four chapters. Chapter 2 provides a description of the materials and methods used in this thesis. The materials section will focus on describing the history of Bonneville Estates Rockshelter and the methods section will describe how the coprolites were selected, processed, and analyzed.
Chapter 3 presents the results of the coprolite analysis. Chapter 4 will integrate all of the subsistence data currently available for Bonneville Estates Rockshelter and examine it in light of the three Optimal Foraging Theory models presented above. Finally, chapter 5 provides a discussion of the coprolite data from Bonneville Estates Rockshelter, placing it within a regional context of other coprolite studies from the Bonneville Basin, and my conclusions to this work.
Chapter 2: Materials and Methods

Over two hundred coprolites were excavated during fieldwork conducted at Bonneville Estates Rockshelter between 2000 and 2003. A sample of 20 coprolites identified as potentially human was selected for dietary analysis. These specimens were recovered from the middle and late Holocene components of Bonneville Estates Rockshelter and are associated with early, middle, and late Archaic occupations. While coprolites were recovered from early Holocene deposits, none of these were identified as potential human coprolites and therefore were not included for analysis in this thesis. The following section discusses the location, formation, environment and occupational history of the rockshelter. It is followed by a discussion of the methods used to prepare and analyze the coprolites for evidence of prehistoric human subsistence strategies employed by the occupants of Bonneville Estates Rockshelter during the middle and late Holocene.

Bonneville Estates Rockshelter

Bonneville Estates Rockshelter is located near the Utah and Nevada border in the eastern Great Basin. The rockshelter is located in the Lead Mine Hills approximately 30 kilometers south of Danger Cave and the town of Wendover, Utah (Figure 2.1) (Goebel et al. 2003; Graf 2007; Rhode et al. 2005). At an elevation of 1,580 m, the rockshelter is associated with the late Pleistocene highstand of pluvial Lake Bonneville. Wave action from the lake carved the large opening from the soft limestones and dolomites that make up the Lead Mine Hills sometime prior to 15,000 B.P. and it would have been available for human occupation after 14,500 B.P. With maximum dimensions of 25 m
wide, 10 m high, and 15 m deep and a southeast exposure the cave would have been attractive to human foragers exploiting the area. While modern vegetation within the vicinity of the rockshelter is dominated by shadscale (*Atriplex confertifolia*), rabbitbrush (*Chrysothamnus* sp.), and indian ricegrass (*Achnatherum hymenoides*); during the terminal Pleistocene the vegetation community was dominated by limber pine (*Pinus*
*flexilis* and sagebrush (*Artemisia tridentata*), suggesting the region was cooler and more mesic than today (Goebel et al. 2003; Rhode et al. 2005).

When discovered by Bureau of Land Management (BLM) employees from the Elko Field Office in 1986, the rockshelter was already being actively looted (Goebel et al. 2003; Graf 2007). P-III Associates, Inc. conducted exploratory excavations within the rockshelter in 1988 to determine if intact cultural deposits remained. Their investigation exposed a well-preserved sequence of cultural strata indicating human occupation of the rockshelter over the past 6,000 yrs (Schroedl and Coulam 1989). In 2000, Bryan Hockett of the Elko, Nevada BLM office and Ted Goebel and Kelly Graf, then of the University of Nevada, Las Vegas, resumed excavations within the rockshelter to determine if earlier deposits existed. As of 2006, the excavations had uncovered 67 m² (approximately 25 percent) of the area within the rockshelter and have exposed deposits dating from the latest Pleistocene and throughout the Holocene (Graf 2007).

Excavations at the rockshelter have focused on two large block areas, the West Block and the East Block (Figure 2.2). Twenty distinct strata spanning the late Pleistocene to the late Holocene have been identified in the West Block excavations (Figure 2.3). The East Block was excavated in area that originally contained a large looters pit, making this area more stratigraphically complex. Prehistoric excavation of several hearths clustered in the northwest corner of the East Block further complicates the stratigraphy in this area of the rockshelter. Eighteen strata have been identified in the East Block spanning the latest Pleistocene through the late Holocene (Figure 2.4). In 2003, a trench connecting the two blocks was opened to facilitate correlation of stratigraphy across the site (Graf 2007).
Six cultural components have been identified at Bonneville Estates documenting human occupation of the rockshelter from the late Pleistocene through the late Holocene (Table 2.1). Human coprolites, however, were only recovered from the middle and late Holocene occupations. With one exception, the coprolites analyzed in this thesis were recovered from the West Block excavations. Specimen CRNV-3425 was recovered from
Figure 2.3. Stratigraphic Profile of West Block Excavations (Graf 2007:84)

Figure 2.4. Stratigraphic Profile of East Block Excavations (Graf 2007:92). The middle and late Holocene strata (strata 9 through 0) have now been correlated to the West Block stratigraphic sequence.
Table 2.1. Bonneville Estates Rockshelter Cultural Components

<table>
<thead>
<tr>
<th>Cultural Component</th>
<th>Strata (West Block)</th>
<th>Major Cultural Period and Diagnostics</th>
<th>Age Estimates (cal yr BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-2</td>
<td>Protohistoric, Desert Side-Notched projectile points</td>
<td>&lt;500</td>
</tr>
<tr>
<td>2</td>
<td>3-4</td>
<td>Late Prehistoric (Fremont?), Rosegate projectile points</td>
<td>~1300-1850</td>
</tr>
<tr>
<td>3</td>
<td>5-10</td>
<td>Middle Archaic, Elko projectile points</td>
<td>~1900-4150</td>
</tr>
<tr>
<td>4</td>
<td>11-13</td>
<td>Early/Middle Archaic, large side-notched projectile points</td>
<td>~5150-5500</td>
</tr>
<tr>
<td>5</td>
<td>14-17a</td>
<td>Early Archaic</td>
<td>~6850-8250</td>
</tr>
<tr>
<td>6</td>
<td>17b-19</td>
<td>Paleoarchaic, Stemmed projectile points</td>
<td>~10,650-12,900</td>
</tr>
</tbody>
</table>

(Source: Rhode 2006)

the East Block excavations. The following discussion gives detailed descriptions of those strata from which human coprolites were recovered. The descriptions are intended to provide a chronological and cultural context for the coprolites analyzed in this thesis.

**Middle Holocene Component**

Grayson (1993) defines the middle Holocene as 7,500 to 4,500 years $^{14}$C years BP. At Bonneville Estates Rockshelter the middle Holocene is represented by strata 17 through 11 (Graf 2007); however human coprolites were only recovered from stratum 14.

**Stratum 14**

Stratum 14 is a thick organic-rich zone containing numerous, well-preserved human coprolites and textiles. The stratum is subdivided into three sub-strata (14c, 14b,
and 14a) based on slight textural differences. Sub-stratum 14c is located directly above stratum 15 and consists of a thick (10 to 30 cm) band of yellowish-brown sandy loam with rare angular gravel- to cobble-sized eboulis clasts. Sub-stratum 14c does not appear to be continuous through the west block excavations, having been exposed in only four excavation units. Sub-stratum 14b ranges from 2 to 20 cm in thickness and is a yellowish-brown sandy loam with abundant to rare angular gravel- to cobble-sized eboulis clasts. Sub-stratum 14a ranges from 2 to 20 cm in thickness and is a yellowish-brown sandy loam with few to many angular gravel- to cobble-sized eboulis clasts. Not all excavated material could be assigned to a sub-stratum and were instead assigned a general stratum 14 provenience. The stratum was formed primarily through anthropogenic and biogenic processes, with lesser effect from geogenic processes (Graf 2007:91). Four radiocarbon age estimates have been obtained for stratum 14; 6280±40, 6100±80, 6100±50, and 6040±80 14C years BP. Calibration of the radiocarbon dates suggests Stratum 14 accumulated over a 600-year period from 7340 to 6690 cal BP (Graf 2007:99).

**Late Holocene Component**

The late Holocene begins at the terminus of the middle Holocene and spans the last 4,500 14C years BP (Grayson 1993). At Bonneville Estates Rockshelter the late Holocene is represented by strata 10 through 0 (Graf 2007); however human coprolites were only recovered from strata 7, 3/4, 2, and 0.
Stratum 7

Stratum 7 is relatively thick (5 to 20 cm) and ranges from a loam to sandy loam texture with alternating organic-rich (grayish-brown in color) zones and silt/ash-rich (ranging from light yellowish-brown to light gray in color) zones. The stratum contains many sub-angular to angular gravel- to cobble-sized eboulis clasts. Several ungulate hair “mats” were noted during excavations of this stratigraphic unit and may represent simply processing features. Other observed organics include shredded bark, wood fragments and dispersed charcoal. This stratum was predominantly formed through anthropogenic means and, to a lesser extent through geogenic and biogenic processes (K. Graf, personal communication 2007). One radiocarbon age estimate of 2250±80 14C years BP was obtained for stratum 7 by Schroedl and Coulam (1989).

Stratum 4

Stratum 4 is not a true geologic stratum; it represents a massive garbage pit associated with the latest Elko occupation in the west block. The stratum ranges in thickness from 0 to 46 cm and consists of a sandy loam with three organic bands (4a, c, d) of very loose dump/trash zones and a single, very thin silt band (4b). The organic zones range from grayish-brown to brown in color, and the silt band is light brownish-gray in color. The stratum contains few to many sub-angular to angular gravel- to cobble-sized eboulis clasts and organic materials including; shredded bark, dispersed charcoal, bone, cactus pads/spines, ungulate hair, and fire-cracked rock. The stratum was predominantly formed through anthropogenic processes (K. Graf, personal communication 2007). One radiocarbon age estimate of 1900 ± 40 14C years BP has been obtained for stratum 4.
Stratum 3

Stratum 3 is a relatively thick (5 to 25 cm) band of organics and sandy loam with many sub-angular gravel-sized eboulis clasts. The sediment ranges from a light yellowish brown to grayish brown in color depending on the amount of organics and charcoal/ash that is present. This stratum was predominantly formed through anthropogenic means and contained a large concentration of organics including rice grass seeds and chaff, shredded bark, wood fragments, and dispersed charcoal (K. Graf, personal communication 2009). Three radiocarbon age estimates have been obtained for Stratum 3; 1710±35, 1415±35, and 1380±60 $^{14}$C years BP.

Stratum 2

Stratum 2 is a relatively thin (1 to 15 centimeters) organic zone. The sediment consists of a very dark grayish brown to a light yellowish brown sandy loam with many sub-angular to angular gravel-sized eboulis clasts. The hulls from pinyon pine are abundant in this stratum. This stratum was formed primarily through anthropogenic means and to a lesser extent, by geogenic and biogenic processes (K. Graf, personal communication 2009). There is no radiocarbon age estimate for stratum 2 but using dates from overlying stratum 1 and underlying stratum 3 it can be assumed to have formed between 1380±60 and 160±30 $^{14}$C years BP.

Stratum 0

Stratum 0 is the modern floor surface of the rockshelter. The sediment is a yellowish-brown to brown sandy loam and contains fill from looters activities within the rockshelter (K. Graf, personal communication 2009).
Methods

Selection

Several criteria have been developed in attempt to visually identify human coprolites from non-human coprolites (Fry 1976). These criteria include size, shape, visible contents, and the color of the fecal matter, as well as the color and degree of opaqueness of the immersing fluid. Within the past two decades several researchers have also utilized various biochemical analyses to determine both the origin of coprolite specimens and dietary constituents (Gilbert et al. 2008; Marlar et al. 2000a, 2000b; Poinar et al. 1998; Rhode 2003).

To support the claim of cannibalism in the American Southwest, Marlar et al. (2000a, 2000b) analyzed a coprolite from the Cowboy Wash Pueblo site. By identifying human-specific proteins and immunoglobulins within the coprolite, the authors were able to positively identify a human origin for the specimen (Marlar et al. 2000b). Previous biochemical analysis identified human myoglobin within the coprolite specimen, indicating that the defecator of the specimen had consumed human flesh (Marlar 2000a). Myoglobin resides in muscle tissue and could only have been introduced to the digestive tract through ingestion.

Rhode (2003) used hormone testing of coprolites from Hidden Cave in northwestern Nevada to address issues of diet, gender, and mobility in the Carson Sink area. Results of the hormone testing indicated that women were the most likely originators of the coprolite specimens found at Hidden Cave. This suggests that the prehistoric inhabitants of the Carson Sink area utilized a gender-based difference in foraging strategies.
DNA analysis has also been employed to aid in the identification of a specimen’s origin as well as dietary items that may not show up in the macroremains (Gilbert et al. 2008; Poinar et al. 1998). Poinar et al. (1998) were the first to develop a technique to extract DNA sequences from coprolite specimens. The test case specimens were recovered from Gypsum Cave in northern Nevada and were visually identified as the dung of an extinct ground sloth whose bones were also found in the cave. Through DNA analysis the researchers were not only able to confirm the ground sloth as the originator of the coprolite specimens but were also able to identify several plant species that were likely part of the animal’s diet although macroremains of these plants were not found. In the northern Great Basin, human DNA was recovered from coprolites dating to 12,300 \(^14\text{C}\) years BP (Gilbert et al. 2008). The coprolites, which were found at the Paisley Five Mile Caves in eastern Oregon, support claims for a pre-Clovis occupation of the Great Basin and have pushed back the timing of human’s earliest entry into the New World by almost 1,000 \(^14\text{C}\) years.

Unfortunately, biochemical analysis was outside the scope of this thesis and therefore the 20 samples were not submitted for DNA or biomolecular analysis. All coprolites from Bonneville Estates Rockshelter were examined according to the criteria established by Fry (1976) and 20 probable human coprolites were selected for further analysis (Table 2.2). [According to Reinhard and Bryant (1992:264) 80 to 90 percent of major dietary constituents within a population will be identified after 15 to 20 coprolites from a site have been analyzed.]

To obtain a diverse sample, coprolites were chosen from as many different proveniences as possible. Stratum 14 contained the largest assemblage of coprolites, and
specimens were selected from substrata 14a and 14c to determine if dietary changes
could be detected over the 600-year period during which stratum 14 was deposited. Only
one probable human coprolite was recovered from the East Block excavations and was
included in this analysis. Two samples were selected from specimen CRNV-7737 and
analyzed separately as it contained several large pieces that appeared to represent
multiple defecations.

Table 2.2. Bonneville Estates Rockshelter Coprolites Chosen for Analysis

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Specimen Number</th>
<th>Excavation Block</th>
<th>Provenience</th>
<th>Level</th>
<th>Stratum</th>
<th>Sample Weight (in grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CRNV-7737a</td>
<td>trench</td>
<td>N5.36, W10.54</td>
<td>3 cm</td>
<td>BD1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>CRNV-7737b</td>
<td>trench</td>
<td>N5.36, W10.54</td>
<td>3 cm</td>
<td>BD</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>CRNV-7853</td>
<td>trench</td>
<td>N5.30, W11.36</td>
<td>11 cm</td>
<td>AD2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>CRNV-7917</td>
<td>trench</td>
<td>N5.25, W11.05</td>
<td>2 cm</td>
<td>BD</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>CRNV-5725</td>
<td>east</td>
<td>N4, W4</td>
<td>unknown</td>
<td>3/4</td>
<td>2.48</td>
</tr>
<tr>
<td>6</td>
<td>CRNV-9588</td>
<td>west</td>
<td>N6.10, W20.22</td>
<td>37 cm</td>
<td>AD</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>CRNV-9355</td>
<td>west</td>
<td>N6.48, W20.89</td>
<td>48 cm</td>
<td>AD</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>CRNV-6682</td>
<td>west</td>
<td>N4, W 15</td>
<td>60-65 cm</td>
<td>BD</td>
<td>14c</td>
</tr>
<tr>
<td>9</td>
<td>CRNV-6703</td>
<td>west</td>
<td>N4.54, W15.25</td>
<td>72 cm</td>
<td>BD</td>
<td>14c</td>
</tr>
<tr>
<td>10</td>
<td>CRNV-6691</td>
<td>west</td>
<td>N4.52, W15.43</td>
<td>70 cm</td>
<td>BD</td>
<td>14c</td>
</tr>
<tr>
<td>11</td>
<td>CRNV-6686</td>
<td>west</td>
<td>N4.55, W15.53</td>
<td>65 cm</td>
<td>BD</td>
<td>14c</td>
</tr>
<tr>
<td>12</td>
<td>CRNV-6687</td>
<td>west</td>
<td>N4.48, W15.40</td>
<td>65 cm</td>
<td>BD</td>
<td>14c</td>
</tr>
<tr>
<td>13</td>
<td>CRNV-3563</td>
<td>west</td>
<td>N5.50, W15.85</td>
<td>26 cm</td>
<td>BD</td>
<td>14a</td>
</tr>
<tr>
<td>14</td>
<td>CRNV-6698</td>
<td>west</td>
<td>N4.59, W15.09</td>
<td>72 cm</td>
<td>BD</td>
<td>14c</td>
</tr>
<tr>
<td>15</td>
<td>CRNV-4482</td>
<td>west</td>
<td>N4.93, W15.92</td>
<td>38 cm</td>
<td>BD</td>
<td>14a</td>
</tr>
<tr>
<td>16</td>
<td>CRNV-4499</td>
<td>west</td>
<td>N4.87, W15.99</td>
<td>38 cm</td>
<td>BD</td>
<td>14a</td>
</tr>
<tr>
<td>17</td>
<td>CRNV-4495</td>
<td>west</td>
<td>N4.87, W15.79</td>
<td>47 cm</td>
<td>BD</td>
<td>14a</td>
</tr>
<tr>
<td>18</td>
<td>CRNV-3423</td>
<td>west</td>
<td>N5.20, W15.50</td>
<td>10 cm</td>
<td>AD</td>
<td>7</td>
</tr>
<tr>
<td>19</td>
<td>CRNV-8440</td>
<td>trench</td>
<td>N5, W12</td>
<td>unknown</td>
<td>7</td>
<td>2.49</td>
</tr>
<tr>
<td>20</td>
<td>CRNV-3425</td>
<td>west</td>
<td>N5.16, W15.50</td>
<td>9 cm</td>
<td>AD</td>
<td>7</td>
</tr>
</tbody>
</table>

Notes: 1BD = below datum
2AD = above datum
**Dating**

Coprolites, as well as other cultural material, are often susceptible to vertical and horizontal displacement in rockshelter settings where pack rat activity and human caching activities can often move objects far from their original deposition (Jenkins 2007; Rhode 2003). To date, two series of 47 radiocarbon dates on charcoal, bone, and textile fragments have been obtained for both the East and West Block excavations (Graf 2007). Whenever possible, radiocarbon samples were selected from hearths and textile fragments. These two series demonstrate that deposits within the rockshelter are intact and have suffered very little disturbance from biological or anthropogenic agents. To confirm that the coprolite specimens analyzed in this thesis were also in good stratigraphic context, samples from eight coprolites were submitted to Beta Analytic for AMS (accelerator mass spectrometry) radiocarbon dating.

**Preparation**

Preparation of the specimens followed methods described by Fry (1985). Representative samples weighing between 2.0 -30.0 g of each specimen were removed for analysis. Each sample was then placed in a 0.5 percent aqueous solution of trisodium phosphate and allowed to soak for at least 10 days. To aid in the breakdown of the fecal matter, the sample jars were shaken daily. Once the material dissolved, the appearance of foam or scum, the presence of a musty or fecal odor, and the degree of opaqueness were observed. The presence of a strong musty or fecal odor and a bacterial scum or foam on the surface of the fluid may indicate consumption of meat whereas the lack of these characteristics may indicate consumption of primarily vegetal material (Fry 1985:133). The color and degree of opaqueness of the fluid, while varying according to major dietary
constituents, may relate to the origin of the specimen (Fry 1976:7). Fry (1976) noted that human fecal matter turned the fluid black while non-human specimens did not.

After the specimens were rehydrated, the material was then poured through a 250-micron screen and allowed to dry. Once dry, the samples were weighed and then sorted for plant macrofossils, charcoal, bone, hair, feathers, insects, and other dietary constituents.

Sorting

Due to the large amount of material rehydrated from each specimen, samples greater than 2.5 g were not fully sorted. Instead a subsample ranging from 0.5 to 3 g was selected for sorting. The bulk from each sample was then scanned for bone and items that did not appear in the subsample. The material was sorted under a 10-60 x binocular dissecting microscope. All identified constituents were quantified on a 5-part ordinal scale of abundance with 1 indicating a rare item (<1 / 0.5g), 2 present but uncommon (1-10 / 0.5g), 3 common (11-100 / 0.5g), 4 abundant (101-500 / 0.5g), and 5 indicating a dominant dietary item (>500 / 0.5g).

Macrobotanical Analysis

Seeds recovered from the specimens were identified using a reference collection assembled by Dr. Dave Rhode of the Desert Research Institute. With the exception of cactus spines and glochids and the rootwad (rhizome) of bulrush (Scirpus sp.), all other plant material was classified into three categories: undifferentiated plant fiber, plant epidermis, and possible cactus parts.
Faunal Analysis

All bone fragments from both the subsample and bulk were recovered. The bone was sent to Dr. Bryan Hockett at the Bureau of Land Management Office in Elko, Nevada for taxonomic identification.
Chapter 3: Analysis Results

Of the 20 coprolites selected for this thesis, 18 coprolites were determined to be of probable human origin and were analyzed for dietary evidence according to the methods described in Chapter 2. Two specimens (CRNV-7737b and CRNV-3563) were removed from further analysis due to probable non-human origin; once rehydrated, these samples were found to have high contents of large bone fragments and animal hair indicating that these were likely carnivore scat. The following sections provide the results of the dietary analysis, as well as the results of the radiocarbon dating.

Chronology

A total of eight coprolites were dated through the AMS radiocarbon dating method (Table 3.1). At least one coprolite from each stratum or sub-stratum was dated. The radiocarbon estimates obtained on the coprolites correlate well with other radiocarbon age estimates obtained from the strata indicating there has been little to no vertical mixing of the materials. Furthermore the dates suggest that the coprolites analyzed in this thesis fall into three separate Cultural Components at Bonneville Estates Rockshelter; Cultural Component 5 (6510±50 to 6050±40 BP), Cultural Component 3 (2090±40 BP), and Cultural Component 1 (440±40 to 50±40 BP).

Diet and Dietary Change

The coprolite analysis shows a heavy reliance on desert resources, particularly small seeds and cactus. Table 3.2 displays the distribution and relative abundance of the coprolite constituents. The most ubiquitous dietary element identified in the coprolites is
Table 3.1. Radiocarbon Dates for Bonneville Estates Rockshelter Coprolites

<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>Stratum</th>
<th>Stratum Date (14C years BP)</th>
<th>Coprolite Date (14C years BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRNV-7853</td>
<td>0</td>
<td>0 to 160±30</td>
<td>400±40</td>
</tr>
<tr>
<td>CRNV-7737a</td>
<td>2</td>
<td>160+/ -30 to 1,415±35</td>
<td>440±40</td>
</tr>
<tr>
<td>CRNV-5725</td>
<td>3/4</td>
<td>1,380±60 to 160±30</td>
<td>50±40</td>
</tr>
<tr>
<td>CRNV-3425</td>
<td>7</td>
<td>2,250±80</td>
<td>2,090±40</td>
</tr>
<tr>
<td>CRNV-4482</td>
<td>14a</td>
<td>6,100±50</td>
<td>6,050±40</td>
</tr>
<tr>
<td>CRNV-4499</td>
<td>14a</td>
<td>6,100±50</td>
<td>6,080±40</td>
</tr>
<tr>
<td>CRNV-6698</td>
<td>14c</td>
<td>6,040±80 to 6,315±40</td>
<td>6,070±40</td>
</tr>
<tr>
<td>CRNV-9588</td>
<td>14c</td>
<td>6,040±80 to 6,315±40</td>
<td>6,510±50</td>
</tr>
</tbody>
</table>

pickleweed (*Allenrollea occidentalis*), which was found in 14 out of the 18 coprolites (~78 percent). The second most ubiquitous identified dietary constituent is small mammal remains which were found in 7 (~39 percent) of the coprolites, followed by large mammal remains, which were also identified in 7 (~39 percent) of the coprolites, and cactus, which was identified in 6 (~33 percent) of the coprolites. Unidentified bone as well as unidentified plant fiber and epidermis comprised a portion of the diet in almost all of the coprolites analyzed. Charcoal was also ubiquitous in the coprolites, indicating the consumption of food cooked in hearths.

The presence of large mammals in the diet is largely represented by pronghorn hair, which was identified (often in great quantities) in six of the coprolites. Ungulate bone was identified in two coprolites and the bone from one of those specimens was tentatively identified as a young pronghorn antelope. It should be noted that both bone and hair from large mammals would not be intentionally digested; therefore, their occurrence in the coprolites can only be taken to indicate the presence, not relative importance, of large mammals in the diet.
Table 3.2 Contents of Bonneville Estates Rockshelter Coprolites

| Catalog number | 7853 | 7737 | 7917 | 5725 | 3423 | 8440 | 3425 | 4482 | 4499 | 4495 | 9588 | 9555 | 6682 | 6703 | 6691 | 6686 | 6687 | 6698 |
|----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Radiocarbon age (14C year BP) | 400±400± | 50± | 2090 | 6050 | 6080 | 6510 | 6070± | 40 |
| Stratum | 0 | 2 | 2 | 3/4 | 7 | 7 | 7 | 14a | 14a | 14a | 14 | 14 | 14c | 14c | 14c | 14c | 14c | 14c | 14c |
| Cultural Component | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

*Seeds (in order of ubiquity in samples)*

- **Pickleweed** *(Allenrollea occidentalis)*
  - 2 1 1 2 2 3 5 5 5 5 5 5 5 5
- **Dropseed Sandgrass** *(Sporobolus sp.)*
  - 4 5
- **Bluegrass** *(Poa sp.)*
  - 5
- **Ricegrass** *(Oryzopsis hymenoides)*
  - 2
- **Beeweed** *(Cleome sp.)*
  - 1
- **Pinyon pine** *(Pinus monophylla)*
  - 1
- **cf Solanacea**
  - 1

*Other vegetal material*

- **Charcoal**
  - 3 2 2 2 2 1 2 3 3 3 3 3 3 3 3 3 3 3
- **Glochids**
  - 1 2 2 1 1
- **Cactus spines**
  - 2
- **Scirpus rhizome shadescule** *(cf Atriplex fruit)*
  - 2
- **Undifferentiated plant fiber**
  - 3 2 2 5 3 4 2 2 2 3 3 2 3 2 2 2 3

*Note: 4\* indicates the presence of a particular component.*
Plant epidermis & 2 & 3 & 2 & 3 & 3 & 3 & 3 & 3 \\
Possible cactus part & 1 & 1 & 2 \\

*Faunal material*

*Neotoma lepida*  
(desert woodrat) & 1 & 1 \\
Rodentia & 1 & 1 & 2 & 1 \\
*Sylvilagus sp.*  
(cottontail bunny) & 1 \\
small mammal & 1 & 1 \\
ungulate & 1 & 1 \\
fish vertebra & 1 \\
unidentified bone & 1 & 2 & 2 & 2 & 2 & 1 & 3 & 2 & 2 & 2 & 1 & 3 & 1 \\
bird feathers & 2 \\
Fish scales & 2 & 1 \\
Insect parts & 3 & 2 & 1 \\
Reptile skin fragments & 2 \\
Pronghorn hair & 2 & 3 & 3 & 2 & 2 & 2 \\
Other hair & 2 & 3 & 4 & 2 & 3 & 3 & 2 & 1 \\

*Other organic material*

Unidentified fibers & 3 & 2 & 2 & 3 & 4 & 4 & 5 & 4 & 3 & 3 & 3 & 4 & 3 \\
Louse/Tick & 1 \\
Unknown organic material & 3 \\

Notes:  
All identified constituents were quantified on a 5-part ordinal scale of abundance with 1 indicating a rare item (<1/0.5g), 2 present but uncommon (1-10/0.5g), 3 common (11-100/0.5g), 4 abundant (101-500/0.5g), and 5 indicating a dominant dietary item (>500/0.5g).  
1 Most likely Scirpus rhizome  
2 Most likely from a young pronghorn antelope
Small mammal remains identified within the coprolites are primarily of the order Rodentia and include the desert woodrat (*Neotoma lepida*) identified in two coprolites and unidentified rodent bone found in four coprolites. Cottontail rabbit (*Sylvilagus* sp.), of the order Lagomorpha, was identified in a single coprolite.

Cactus remains consist of spines and glochids (tiny, barbed spines that occur in clusters around the areoles of some cacti). They were not identified to a specific genus due to the lack of experience on the part of the analyst, but it is likely that they are from the prickly pear (*Opuntia* sp.) cactus. Prickly pear is common in the area today and remains were identified at nearby Hogup and Danger Caves indicating that they were a common component of the diet in prehistoric times (Fry 1980). It is likely that the unidentified plant epidermis noted in several of the coprolites is actually the tissue of prickly pear pads.

Marsh (wetland) resources do not appear to have been an important part of the diet at Bonneville Estates Rockshelter. Fish remains were identified in less than 20 percent (N=3) of the coprolites and bulrush was found in only one coprolite. As mentioned earlier the coprolites analyzed in this thesis are from three separate Cultural Components (5, 3, and 1). Coprolites within each of these periods share similar dietary characteristics that differentiate them from coprolites of other periods.

**Cultural Component 5 Coprolites**

The majority (N = 11) of the coprolites analyzed in this thesis belong to Cultural Component 5. All of the coprolites from Cultural Component 5 were recovered from Stratum 14 and its sub-strata which span approximately 600 years. These coprolites are characterized by high amounts of pickleweed seeds, in most cases exceeding 500 seeds.
per a 0.5 g sample. Three of the coprolites also contain high amounts of dropseed sandgrass (*Sporobolus* sp). A single seed of a beeweed plant (*Cleome* sp.) was found in one coprolite. Cactus remains were found in three coprolites. Bone fragments were found in all but one coprolite indicating animal protein was an important component of the diet. A few of the bone fragments were large enough to identify and included cottontail rabbit, small mammal, and ungulate.

Two distinct diets appear to be represented in this coprolite sample; 1) a pickleweed diet, and 2) a diet of dropseed sandgrass that is often mixed with pickleweed. All three samples containing dropseed were directly radiocarbon dated to 6050±40, 6080±40, and 6070±40 BP. All three dates overlap at one standard deviation (or sigma), suggesting that they were deposited during a single visit to the rockshelter. One other coprolite was radiocarbon dated to 6510±50 BP. This coprolite contained high amounts of pickleweed and no dropseed. This suggests that the pickleweed-only diet is older than the dropseed diet.

Both pickleweed and dropseed sandgrass set seed in late summer through early fall (although pickleweed may be collected into the spring of the following year). The presence of both seeds in these coprolites strongly indicates that human foragers visited Bonneville Estates Rockshelter during this time of the year.

The Cultural Component 5 coprolite sample indicates a strong adaptation to desert resources (with the exception of pickleweed which is a playa plant). Only minor utilization of wetland resources is indicated during this period by the identification of a fish scale in one coprolite and a few small bird feathers in another coprolite. Both of those coprolites also contain mammal bone and small dryland seeds, suggesting that
wetland resources were secondary in the diet and may have been included
opportunistically. However, since the wetland resources were transported to the site from
at least 4-5 kilometers away their importance to the diet may be greater than the data
suggests. Overall, the Cultural Component 5 coprolites contain a diverse set of resources,
including both seeds and animal resources, which indicate a broad diet breadth.

Cultural Component 5 Coprolites

Three of the coprolites analyzed in this thesis belong to Cultural Component 3. All three of these coprolites were recovered from Stratum 7. These coprolites are characterized by the absence of seeds. Although the sample size is small, a dichotomy exists in the Cultural Component 3 coprolite sample between wetland and dryland resources. One of the coprolites from this period was almost entirely composed of the masticated root wad (or rhizome) of bulrush. Bulrush is commonly found in marshes along the edge of the Bonneville Salt Flats and could have been easily procured from the Blue Lake wetlands, which at present day are located 6 km east of the rockshelter. In addition to a few fragments of charcoal, the only other dietary constituents in this coprolite were a handful (less than 10) of fragments of unidentified bone and a single fish vertebra (which was also likely procured from the marsh). The other two coprolites from this period have no evidence of the utilization of wetland resources. Both of these coprolites contain cactus, rodent bone, and pronghorn hair, indicating a diet focused on dryland resources.

Because no seeds were identified in the Cultural Component 3 coprolite sample, the season of occupation of the rockshelter cannot be determined for this period. This
lack of seeds in the diet also indicates the occupants during this period had a very narrow diet breadth.

Although the Cultural Component 3 coprolite sample is small, it nonetheless suggests a strong focus on both wetland and dryland resources. The cause of the dichotomy between wetland and dryland resources in the diet during this period is not entirely clear, although seasonality, reduced resource availability, or transport costs may be important factors at play here. Minor utilization of wetland resources occur in both the Cultural Component 5 and Cultural Component 1 coprolites, but these resources are always combined with dryland resources.

*Cultural Component 1 Coprolites*

Four of the coprolites analyzed in this thesis belong to Cultural Component 1. The coprolites from this sample were recovered from Stratum 3/4 in the East Block and Stratums 2 and 0 in the West Block. These coprolites are characterized by minor amounts of pickleweed in addition to a diversity of other seeds including bluegrass (*Poa* sp.), Indian ricegrass, pinyon pine (*Pinus monophylla*), an unknown seed of the Solanaceae family, and a few other unknown seeds. Rodent bone, insects, and pronghorn hair are also common in coprolites from this period. Reptile skin fragments were identified in one coprolite and constitute the only known occurrence of reptiles in the diet. Fish scales were also noted in a single coprolite from this period, indicating minor use of wetland resources during this period (although once again their importance to the diet may be greater than indicated by the coprolite data).

It is exciting to find a member of the Solanaceae family in a human coprolite from the rockshelter because many important agricultural plants such as potato, chili pepper,
tobacco, tomato, and eggplant, as well as other ethnobotanically used plants such as nightshade belong to this plant family. Although the recovered seed could not be identified to a specific genus, it does offer the tantalizing possibility for the use of cultigens at Bonneville Estates Rockshelter.

The mixture of seeds identified in the Cultural Component 1 coprolites is interesting because they are not all available at one time of the year. Both ricegrass and bluegrass set seed in the late spring to early summer while pickleweed and pinyon pine seeds are available in the late summer to early fall. The presence of both early summer and late summer seed crops suggests that the rockshelter was visited at least twice a year during this period. In two instances early summer resources were found in the same coprolites containing late summer resources indicating that the rockshelter was used to store the early summer seeds.

The coprolite sample from Cultural Component 1 indicates a strong focus on dryland resources, in particular small seeds. Although the sample size is small, a greater diversity of small seeds was noted from this period than in the Cultural Component 5 coprolite sample, indicating that the later occupants of the rockshelter had an even broader diet breadth than the earlier occupants. The evidence for storage of seeds also supports the conclusion of an increased focus on seed resources during the later period occupation.

Change through Time

Changes in the diet at Bonneville Estates Rockshelter are evident in the three occupation periods presented in this analysis and indicate narrowing and broadening of the diet breadth over time. While there is continuity in the utilization of dryland
resources, there are notable differences in the composition of the diets between Cultural Components 5, 3, and 1 (Figure 3.1). The most notable difference is the utilization of seeds in the diet during each of these periods. Three seed taxa (pickleweed, dropseed sandgrass, and beeweed) were identified in the Cultural Component 5 sample while no seeds were identified in the Cultural Component 3 sample and five taxa of seeds (pickleweed, bluegrass, ricegrass, pinyon pine, and an unidentified seed of the Solanaceae family) were identified in the Cultural Component 1 sample. Additionally, the number of coprolites containing more than one seed taxon increased from 27 percent (N = 3) of Cultural Component 5 coprolites to 75 percent (N = 3) of Cultural Component 1 coprolites. The greater diversity of seeds and the increased number of seed taxa per coprolite during the Cultural Component 1 suggest a broadening of the diet breadth from earlier periods.

There are also notable changes in the utilization of faunal resources in the diet during all three occupation periods. The Cultural Component 5 coprolites contain six identified taxa (rodents, cottontail rabbit, pronghorn, fish, bird, and insects) while three taxa (rodents, fish, and pronghorn) were identified in the Cultural Component 3 coprolites and five taxa (rodents, pronghorn, fish, reptiles, and insects) were identified in the Cultural Component 1 coprolites. Pronghorn antelope, rodents, and fish are found in coprolites from all three periods suggesting that these were staples in the diet. The addition of cottontail rabbit, bird, reptiles, and insects in the Cultural Component 5 and Cultural Component 1 coprolites indicates a broadening of the diet breadth during these periods.
Both the Cultural Component 5 and Cultural Component 1 coprolite samples contain a diverse set of resources, indicating a broad diet breadth during these periods. The evidence for use of stored resources during Cultural Component 1 in addition to the greater diversity of seed resources indicate that the diet breadth of the later occupants was even broader than that of the earlier occupants. The absence of seeds in the Cultural Component 3 coprolites in addition to the small number of faunal resources utilized indicate the occupants during this time had a narrow diet breadth focused on a
few key resources. However, it must be kept in mind that the coprolites analyzed here make up only one line of subsistence evidence and that these data must be combined with other types of subsistence data (e.g., faunal and botanical) in order to provide a more complete picture of the prehistoric diet of the Bonneville Estates Rockshelter occupants.

Conclusion

The coprolite record from Bonneville Estates Rockshelter indicates that subsistence strategies of prehistoric human foragers in the eastern Great Basin have changed over the past 6,000 years. In particular, the Bonneville Estates Rockshelter coprolite data records changes in the intensity of use of small seed resources. While faunal resources are found consistently in coprolites from all three cultural components, seeds are less consistently included in the diet. The evidence for use of stored seeds during the Cultural Component 1 occupation is indicative of high-intensification of these resources and suggests that human foragers visiting Bonneville Estates Rockshelter during this time had the broadest diet breadth of any of the Cultural Components analyzed here. The coprolite data from Bonneville Estates Rockshelter also suggests continuity in the diet. Coprolites from all three Cultural Components analyzed in this thesis indicate a strong focus on dryland resources with wetland resources appearing to be secondarily included in a diet focused on terrestrial resources. The next chapter will combine the coprolite data with other dietary evidence from the faunal and botanical assemblages from Bonneville Estates Rockshelter to create as clear a picture as possible of prehistoric human foraging behavior during the middle and late Holocene and evaluate the subsistence strategies of the occupants within the framework of Optimal Foraging Theory.
Chapter 4: Middle and Late Holocene Subsistence Strategies
at Bonneville Estates Rockshelter

This thesis has three goals. The first is to provide data from the analysis of macro remains that were recovered from a series of human coprolites from the middle and late Holocene occupation of Bonneville Estates Rockshelter (which is provided in the preceding chapter). The second is to reconstruct the subsistence strategies employed by the middle and late Holocene foragers. The final goal of this thesis is to examine these subsistence strategies within the framework of Optimal Foraging Theory models.

This chapter is devoted to the last two goals of this thesis. Two discussions follow. The first discussion will combine the available faunal and macrobotanical data for Bonneville Estates Rockshelter with the coprolite data provided earlier in this thesis to provide as clear a picture as possible of the subsistence of the middle and late Holocene occupants. The second discussion will examine the subsistence patterns seen at Bonneville Estates Rockshelter within the framework of Optimal Foraging Theory models to determine if the middle and late Holocene occupants were optimal foragers.

Middle and Late Holocene Subsistence at Bonneville Estates Rockshelter

Cultural Component 5

The coprolite data from Cultural Component 5 indicates a diverse diet focused on dryland resources, particularly the seeds of pickleweed and dropseed sandgrass, and a minor utilization of wetland resources. Dietary items found in Component 5 coprolites include the bones of cottontail rabbit, small mammals, and ungulates, bird feathers, fish scales, insect exoskeleton, pronghorn hair, other unidentified animal hair, cactus spines,
unidentified plant fiber and epidermis, and the seeds of pickleweed, dropseed sandgrass, and beeweed.

The faunal assemblage from this period was analyzed by Hockett (2007). Here I will only discuss the results for the faunal assemblage from Stratum 14 because it directly corresponds to the coprolite assemblage for Cultural Component 5. The faunal assemblage from Stratum 14 consists of 881 fragments of bone of which approximately 88 percent (N = 772) were attributed to human foraging activities. Eighty percent (N = 621) of the human derived faunal assemblage is comprised of large mammal bone. Artiodactyls, and in particular pronghorn, appear to have been the prey of choice for human hunters during this period. The remaining 20 percent (N = 151) of the faunal assemblage is comprised of small game including jackrabbit (which makes up half of the small mammal remains), sage grouse (N = 16), and unidentified burned small mammal bone (N = 58).

Analysis of the botanical remains from the hearths and other features from this period was conducted by Rhode (2006). The fill from one hearth feature from this period has been analyzed and contains a wealth of macrobotanical remains that are assumed to be of dietary origin. These include the seeds of pickleweed, goosefoot, shadscale, ricegrass, cactus seeds and pads, and pinyon pine cones and nut hulls. Although cattail seeds, which had to be brought to the cave by humans, were also identified in the hearth feature, it is likely that they were not a dietary item but rather brought into the cave with cattail fluff as a convenient and efficient fire starter.

Combined, the data from the coprolite, faunal, and macrobotanical assemblages from this Component indicates that human foragers exploited a diverse set of resources
including artiodactyls (in particular pronghorn), jackrabbit, cottontail rabbit, sage grouse, insects, fish, cactus, pickleweed, dropseed, beeweed, goosefoot, shadscale, ricegrass, and pinyon pine.

**Cultural Component 3**

Although the sample size is small (N = 3), the coprolite data from Cultural Component 3 indicates a narrow diet focused on a few key resources. Two of the coprolites from this period contained cactus, rodent bone, pronghorn hair, other unidentified animal hair, and unidentified plant fibers and epidermis. The other coprolite from this period contained only bulrush rhizome and a single fish vertebra.

The faunal assemblage from this period was analyzed by Baker (2006). Although Baker analyzed the faunal assemblages from Stratums 9, 7, and 5, I will only discuss the results for the Stratum 7 assemblage because it directly corresponds to the coprolite assemblage for Cultural Component 3. The Stratum 7 faunal assemblage consists of 10,662 fragments of bone that were primarily attributed to human hunting activities. Seventy-seven percent (N = 8,187) of the faunal assemblage consisted of large mammal bone. Approximately 5 percent (N = 395) of the large mammal remains were identified at least to taxonomic order. All identified large mammal bone was of the order Artiodactyla and included pronghorn, mountain sheep, bison, and mule deer. Pronghorn was the most prevalent large mammal, comprising 46 percent (N = 181) of the identified large mammal assemblage. Several “mats” of ungulate hair, most likely pronghorn, were noted in Stratum 7 which corresponds to the Middle period occupation. These features were interpreted as processing areas for pronghorn kills. The remaining 23 percent (N =
of the faunal assemblage consists of small mammal remains that were not taxonomically identified.

Five features from Cultural Component 3 have been analyzed for macrobotanical remains (Rhode 2006). A diverse set of plant resources have been identified in the features from this Component and include pinyon pine nuts, cactus pads and seeds, bulrush seeds and rhizomes, ricegrass and other grass seeds, shadscale fruits, mustard seeds, goosefoot seeds, and cliffbush seeds. Bulrush seeds and particularly the rhizome were found often in great quantities in some of the features suggesting that this was an important component of the diet during this period.

In contrast to the coprolite data alone, which indicated a narrow diet during this period, the combined coprolite, faunal, and macrobotanical data indicates that a diverse set of resources were exploited including artiodactyls (particularly pronghorn), rodents, fish, cactus, pinyon pine, bulrush, ricegrass and other grasses, Shadscale, mustard, goosefoot, and cliffbush.

Cultural Component 1

The coprolite data from Cultural Component 1 indicates a diverse diet focused on small dryland seeds. Dietary items include the seeds of pickleweed, bluegrass, ricegrass, pinyon pine, and the Solanaceae family, cactus spines, shadscale fruit, unidentified plant fibers and epidermis, the bones of rodents and ungulates (artiodactyls), fish scales, insect exoskeleton, reptile skin, pronghorn hair, and other unidentified animal hair.

Three features from Cultural Component 1 have been analyzed for macrobotanical remains (Rhode 2006). Prickly pear cactus dominates the plant assemblage. Cactus pad tissue and spines were common but a seed was also recovered
indicating that the fruit was also used. Other macrobotanicals recovered from the features in this Component include bulrush seeds, ricegrass seeds, shadscale fruits, and a fragmentary maize kernel.

The analysis of the faunal assemblage from this period has not yet been completed. However, the combined data from the coprolite and macrobotanical assemblages suggests that a broad set of resources were exploited including artiodactyls (particularly pronghorn), rodents, fish, reptiles, insects, cactus, pickleweed, bluegrass, ricegrass, pinyon pine, bulrush, and shadscale, maize, and an unknown member of the Solanaceae family. It is interesting to note that several cultivars belong to the Solanaceae family including potato, chili pepper, tobacco, tomato, and eggplant. Although it is likely that the seed recovered from the coprolite belongs to one of the many other non-cultivar members of this family such as nightshade, its co-occurrence with maize tantalizes us with the possibility of a subsistence strategy at Bonneville Estates Rockshelter that relied in part on agricultural crops.

Discussion

The previous analysis illustrates the utility of combining multiple data sets to reconstruct prehistoric subsistence patterns. It is clear that different contexts affect the preservation of resources and therefore affect our interpretation of prehistoric subsistence. By combining the three data sets (coprolite, faunal, and macrobotanical) available from Bonneville Estates Rockshelter, it is possible to obtain a clearer picture of the subsistence of the middle and late Holocene occupants. For instance, both pinyon pine and ricegrass were identified in features from Cultural Components 5 and 3 but were only recovered from human coprolites dating to Cultural Component 1. Other resources
identified from non-coprolite contexts include sage grouse, goosefoot, mustard, cliffbush, and maize. Conversely, resources such as fish, bluegrass, beeweed, and dropseed sandgrass were identified only in coprolites.

There are several reasons why the analysis of the macro remains from the coprolites is at variance with the data from the faunal and botanical assemblages: 1) it could be that these resources are yet to be found in other portions of the cave (for example, dropseed sandgrass has been identified in Cultural Components 2 and 6 but has not been identified in the handful of features that have been analyzed from the other Cultural Components); 2) it is possible that some resources were processed and consumed elsewhere before being deposited at Bonneville Estates Rockshelter through defecation; 3) some resources may have been completely digested in the intestinal tract; and 4) it is possible that some of the identified resources (especially some of the botanical resources) may have not been part of the diet (such as the cattail seeds) or brought into the rockshelter by vectors other than humans (e.g., wind and burrowing animals). Further research will be needed to determine if any one or all of these may be the case.

**Optimal Foraging Theory and Subsistence at Bonneville Estates Rockshelter**

In this next section I will examine the subsistence patterns observed for the middle and late Holocene foragers at Bonneville Estates Rockshelter within the framework of Optimal Foraging Theory. As stated in the first chapter, the central hypothesis of Optimal Foraging Theory is that foragers will always forage in a manner that optimizes their net return rate of energy (calories harvested per unit of foraging time). Anthropologists commonly apply three models to anthropological and
archaeological data to determine if human foragers are behaving in accordance with Optimal Foraging Theory. These models are Diet Breadth, Patch Choice, and Central Place Foraging, the basic structures of which are described in detail in the first chapter of this thesis. Each model develops certain predictions to determine if foragers are behaving in a way that optimizes their net return rate of energy. I will now compare the available subsistence data from the middle and late Holocene occupations of Bonneville Estates Rockshelter to the predictions of each of the three models to determine if they were optimal foragers.

*The Diet Breadth Model*

The Diet Breadth Model makes two predictions about how foragers make their decisions. The first prediction is that foragers will always forage in a manner that optimizes their net return rate of energy. That is, foragers will focus on those resources that provide the most calories for the least amount of work. As these high-ranked resources become scarcer in the environment, foragers will begin to broaden their diet breadth by including resources that provide lower energy returns to make up the difference in lost calories. Higher ranked resources are never dropped from the diet but as they become less available lower ranked resources become more prevalent. The second prediction is that resources are added to the diet in decreasing order of their energy value.

In the past two decades Great Basin archaeologists have devoted considerable time to establishing return rates for many of the common resources known to be used both in ethnographic and prehistoric times (Barlow and Metcalfe 1996; Madsen and Schmitt 1998; Simms 1987). Table 4.1 displays the post-encounter return rates
Table 4.1. Experimental Post-Encounter Return Rates for Common Great Basin Food Resources (based on information in Kelly 1995:81)

<table>
<thead>
<tr>
<th>Taxa (common name)</th>
<th>Resource Type</th>
<th>Return rate (kcal/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Anabrus simplex</em> (grasshopper)</td>
<td>insect</td>
<td>41,598-714,409</td>
</tr>
<tr>
<td><em>Odocoileus hemionus</em> (deer)</td>
<td>mammal</td>
<td>17,971-31,450</td>
</tr>
<tr>
<td><em>Ovis canadensis</em> (sheep)</td>
<td>mammal</td>
<td>17,971-31,450</td>
</tr>
<tr>
<td><em>Antilocapra americana</em> (antelope)</td>
<td>mammal</td>
<td>15,725-31,450</td>
</tr>
<tr>
<td><em>Lepus</em> sp. (jackrabbit)</td>
<td>mammal</td>
<td>13,475-15,400</td>
</tr>
<tr>
<td><em>Thomomys</em> sp. (gopher)</td>
<td>mammal</td>
<td>8,983-10,780</td>
</tr>
<tr>
<td><em>Sylvilagus</em> sp. (rabbit)</td>
<td>mammal</td>
<td>8,983-9,800</td>
</tr>
<tr>
<td><em>Typha latifolia</em> (cattail)</td>
<td>pollen</td>
<td>2,750-9,360</td>
</tr>
<tr>
<td><em>Spermophilus</em> sp. (squirrel)</td>
<td>mammal</td>
<td>5,390-6,341</td>
</tr>
<tr>
<td><em>Citellus</em> sp. (squirrel)</td>
<td>mammal</td>
<td>2,837-3,593</td>
</tr>
<tr>
<td><em>Anas</em> sp. (duck)</td>
<td>waterfowl</td>
<td>1,975-2,709</td>
</tr>
<tr>
<td><em>Quercus gambeli</em> (gambel oak)</td>
<td>seed</td>
<td>1,488</td>
</tr>
<tr>
<td><em>Descurainia pinnata</em> (tansy mustard)</td>
<td>seed</td>
<td>1,307</td>
</tr>
<tr>
<td><em>Gila bicolor</em></td>
<td>minnow</td>
<td>750-7,514</td>
</tr>
<tr>
<td><em>Pinus monophylla</em> (pinyon pine)</td>
<td>seed</td>
<td>841-1,408+</td>
</tr>
<tr>
<td><em>Lewisia rediviva</em> (bitterroot)</td>
<td>root</td>
<td>1,237</td>
</tr>
<tr>
<td><em>Elymus salinus</em> (salina wild rye)</td>
<td>seed</td>
<td>921-1,238</td>
</tr>
<tr>
<td><em>Atriplex nuttallii</em> (shadscale)</td>
<td>seed</td>
<td>1,200</td>
</tr>
<tr>
<td><em>Atriplex confertifolia</em> (shadscale)</td>
<td>seed</td>
<td>1,033</td>
</tr>
<tr>
<td><em>Scirpus</em> sp. (bulrush)</td>
<td>seed</td>
<td>302-1,699</td>
</tr>
<tr>
<td><em>Echinochloa crusgalli</em> (barnyard grass)</td>
<td>seed</td>
<td>702</td>
</tr>
<tr>
<td><em>Lepidium fremontii</em> (peppergrass)</td>
<td>seed</td>
<td>537</td>
</tr>
<tr>
<td><em>Helianthus annuus</em> (sunflower)</td>
<td>seed</td>
<td>467-504</td>
</tr>
<tr>
<td><em>Poa</em> sp. (bluegrass)</td>
<td>seed</td>
<td>418-91</td>
</tr>
<tr>
<td><em>Elymus salinus</em> (wild rye)</td>
<td>seed</td>
<td>266-473</td>
</tr>
<tr>
<td><em>Oryzopsis hymenoides</em> (ricegrass)</td>
<td>seed</td>
<td>301-92</td>
</tr>
<tr>
<td><em>Phalaris arundinacea</em> (reed canary grass)</td>
<td>seed</td>
<td>261-321</td>
</tr>
<tr>
<td><em>Muhenbergia aperifolia</em> (scratchgrass)</td>
<td>seed</td>
<td>162-294</td>
</tr>
<tr>
<td><em>Hordeum jubatum</em> (foxtail barley)</td>
<td>seed</td>
<td>138-273</td>
</tr>
<tr>
<td><em>Carex</em> sp. (sedge)</td>
<td>seed</td>
<td>202</td>
</tr>
<tr>
<td><em>Typha latifolia</em> (cattail)</td>
<td>root</td>
<td>128-267</td>
</tr>
<tr>
<td><em>Scirpus</em> sp. (bulrush)</td>
<td>root</td>
<td>160-257</td>
</tr>
<tr>
<td><em>Distichlis stricta</em> (saltgrass)</td>
<td>seed</td>
<td>146-60</td>
</tr>
<tr>
<td><em>Allenrolfea occidentalis</em> (pickleweed)</td>
<td>seed</td>
<td>90-150</td>
</tr>
<tr>
<td><em>Sitanion hystrix</em> (squirreltail grass)</td>
<td>seed</td>
<td>91</td>
</tr>
</tbody>
</table>
(measured in kilocalories per hour) for several Great Basin resources in decreasing order of rank.

If the middle and late Holocene occupants of Bonneville Estates Rockshelter were optimal foragers according to the Diet Breadth Model, we should see diets with high-ranked resources always included when available and, as diet breadth broadens, the inclusion of lower-ranked resources in decreasing order of their rank. The average post-encounter return rates are known for 11 of the resources commonly found in the diet at Bonneville Estates Rockshelter. These will be used to create an optimal diet set for the rockshelter (Figure 4.1). The following sections will compare the diets of each of the three Cultural Components (5, 3, and 1) discussed in this thesis to the optimal Bonneville Estates diet in an attempt to determine whether the middle and late Holocene occupants were optimal foragers according to the Diet Breadth Model.

**Cultural Component 5.** Figure 4.2 displays the diet breadth of the occupants of Cultural Component 5 at Bonneville Estates Rockshelter in comparison to the optimal Bonneville Estates diet. The occupants of Component 5 had a broad diet breadth that included both the highest-ranked and lowest-ranked items in the optimal diet set. The Cultural Component 5 diet included the three highest ranked resources in the optimal Bonneville Estates diet: pronghorn (~24,000 kilocalories per hour), cottontail rabbit (~9,400 kilocalories per hour), and minnows (~4,100 kilocalories per hour). The two lowest ranked items: ricegrass (~200 kilocalories per hour) and pickleweed (~120 kilocalories per hour) were also a major component in the diet. Interestingly enough, however, is the almost near absence of items from the middle of the optimal diet set. Only pinyon pine and shadscale (both with about an average return rate of 1,000
kilocalories per hour) are included from the mid-ranked resources. Mustard, bulrush seeds, bluegrass, and bulrush rhizome are all absent from the diet even though they provide a higher return rate than both ricegrass and pickleweed, which are included in the diet.

![Graph Displaying the Optimal Bonneville Estates Rockshelter Diet](image)

Figure 4.1. Graph Displaying the Optimal Bonneville Estates Rockshelter Diet

The diet of the Cultural Component 5 occupants meets the first prediction of the Diet Breadth Model (highest ranked items are always included in the diet) but not assumption 2 (that items are added to the diet in decreasing order of their rank). The highest-ranked items are included within the diet, indicating that the prehistoric foragers...
attempted to maximize their net return rate of energy. However, as additional resources were added to the diet they do not appear to have been added in decreasing order of rank as the Diet Breadth Model predicts. Instead the lowest-ranked resources within the optimal diet set are included while other higher ranked resources are excluded, suggesting that the Cultural Component 5 occupants were not foraging in an optimal fashion. If the Cultural Component 5 occupants were optimal foragers according to the Diet Breadth Model, these items, if available, should have been included before the addition of ricegrass and pickleweed, which are the lowest ranked items, into the diet.

Figure 4.2. Graph Displaying the Diet Breadth of Cultural Component 5
Cultural Component 3. Figure 4.3 displays the diet breadth of the occupants of Cultural Component 3 at Bonneville Estates Rockshelter in comparison to the optimal Bonneville Estates diet.

![Graph Displaying the Diet Breadth of Cultural Component 3](image)

Figure 4.3. Graph Displaying the Diet Breadth of Cultural Component 3

Although the analysis of coprolites from this period indicated a narrow diet breadth, the combined dietary evidence indicates that the occupants of Cultural Component 3 had a broad diet breadth that included eight of the 11 resources in the optimal diet set. The highest-ranked resource (pronghorn) is included in the diet, indicating that the Cultural Component 3 occupants were optimizing their diet. With the exception of the absence of cottontail rabbit and bluegrass in the diet, additional items in
the diet appear to be added in decreasing order of rank with the lowest-ranked resource (pickleweed) excluded from the diet. The Cultural Component 3 occupants appear to conform to both predictions of the Diet Breadth Model.

**Cultural Component 1.** Figure 4.4 displays the diet breadth of the occupants of Cultural Component 1 at Bonneville Estates Rockshelter in comparison to the optimal Bonneville Estates diet.

![Figure 4.4. Graph Displaying the Diet Breadth of Cultural Component 1](image)

The occupants of Cultural Component 1 had a broad diet breadth that included eight of the 11 resources in the optimal diet set. The highest-ranked resource (pronghorn)
is included in the diet, indicating that the Cultural Component 1 occupants were optimizing their diet in accordance with the first assumption of the Diet Breadth Model. The occupants of Cultural Component 1 also included the lowest-ranked resource (pickleweed) in their diet. If the Cultural Component 1 occupants were optimal foragers according to the Diet Breadth Model, then all resources within the optimal diet set should be included however this is not the case. At least three resources (including cottontail rabbit, mustard, and bulrush rhizome) with higher return values than pickleweed are excluded from the diet. This exclusion of higher-ranked items suggests that the Cultural Component 1 occupants did not add resources to their diet in decreasing order of their rank and therefore do not conform to the second assumption of the Diet Breadth Model.

Discussion. All three Cultural Components exhibit broad diet breadths (Figure 4.5). There is continuity in the diet through time, particularly in the use of certain resources such as large game (artiodactyls and in particular pronghorn), fish, pinyon pine, bulrush, ricegrass, shadscale, and pickleweed. Other resources, however, such as cottontail rabbit, bluegrass, and mustard appear to have had a more transitory position in the diet (Table 4.2).

The diets of all three Cultural Components meet the first prediction of the Diet Breadth Model: the highest-ranked resource is always included in the diet. Only the diet of Cultural Component 3, however, appears to meet the second prediction of the Diet Breadth Model; that is, resources are added to the diet in decreasing order of their rank. The diets of Cultural Components 5 and 1 include both the highest ranked and the lowest ranked items but are missing most of the mid-ranked resources. This would suggest that the occupants of Cultural Components 5 and 1 were not optimal foragers according to the
Diet Breadth Model. However, since these Cultural Components meet the first prediction of the Diet Breadth Model it would indicate that they were foraging in a manner to optimize their energy intake. What then can explain the absence of some mid-ranked resources in the diets of Cultural Components 5 and 1 when both the highest-ranked and the lowest-ranked items are included? One possible explanation is local environmental factors that changed over time resulting in the absence of these mid-ranked resources within the foraging range of the occupants of Cultural Components 5 and 1. Another possible explanation is that pickleweed, which is a major component of the diets of both Cultural Components 5 and 1, may provide greater returns than experimental data have
shown (Barlow and Metcalfe 1996; Simms 1983). [Preliminary research by John Grant has suggested that pickleweed returns may be greater when collected in the winter / early spring (Dave Rhode, personal communication 2010)]. If this is the case, then the absence of the supposed mid-ranked resources in the diets during both of these Cultural Components may not in fact violate the predictions of the Diet Breadth Model.

Table 4.2. Dietary Composition of Bonneville Estates Rockshelter Occupants During the Middle and Late Holocene

<table>
<thead>
<tr>
<th>Resource</th>
<th>Cultural Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>pronghorn</td>
<td>♦</td>
</tr>
<tr>
<td>cottontail rabbit</td>
<td>♦</td>
</tr>
<tr>
<td>sagegrouse</td>
<td>♦</td>
</tr>
<tr>
<td>rodents</td>
<td></td>
</tr>
<tr>
<td>fish</td>
<td>♦</td>
</tr>
<tr>
<td>reptiles</td>
<td></td>
</tr>
<tr>
<td>insects</td>
<td></td>
</tr>
<tr>
<td>cactus</td>
<td>♦</td>
</tr>
<tr>
<td>pickleweed</td>
<td>♦</td>
</tr>
<tr>
<td>dropseed</td>
<td></td>
</tr>
<tr>
<td>ricegrass</td>
<td>♦</td>
</tr>
<tr>
<td>pinyon pine</td>
<td>♦</td>
</tr>
<tr>
<td>shadscale</td>
<td>♦</td>
</tr>
<tr>
<td>bluegrass</td>
<td></td>
</tr>
<tr>
<td>mustard</td>
<td></td>
</tr>
<tr>
<td>cliffbush</td>
<td></td>
</tr>
<tr>
<td>bulrush (seeds)</td>
<td></td>
</tr>
<tr>
<td>bulrush (rhizome)</td>
<td></td>
</tr>
<tr>
<td>goosefoot</td>
<td>♦</td>
</tr>
<tr>
<td>beeweed</td>
<td></td>
</tr>
<tr>
<td>maize</td>
<td></td>
</tr>
</tbody>
</table>
Another possibility is that the ranks developed for many of the resources exploited by Great Basin foragers are erroneous. Resource ranking within the Diet Breadth Model is based on the net return rate of the individual resource (e.g., a single rabbit, one minnow, a spikelet of pickleweed) but in the real world of human foragers resources are usually collected en masse rather than individually (e.g., a rabbit drive, fish nets and weirs, a basketful of seeds). Because resources are usually collected in large numbers, the abundance and availability of resources become important factors in determining a resource’s rank. As a result, the addition of several factors such as environment (where and how resources are located on the landscape, changes in weather, seasonality), technology and method of capture, and transportation costs must be considered when assessing human foraging behavior. Both the Patch Choice and Central Place Foraging models address resource ranking as a fluid process that changes in response to these additional external factors. It may be that the apparent absence of mid-ranked resources in the diets of Cultural Components 5 and 1 does not reflect a decrease in foraging efficiency but rather a change in the ranking of those resources from mid- to low-ranked. If this is the case, then either Patch Choice or Central Place Foraging may provide better models of optimality for the middle and late Holocene foragers of Bonneville Estates Rockshelter.

*The Patch Choice Model*

Unlike the Diet Breadth Model which considers resources on the level of the individual, the Patch Choice Model states that resources are clustered on the landscape in patches. Resource ranking is based on the net return rate of the patch. The consequence is that resource ranking within the Patch Choice Model is fluid, with resources changing
rank based on abundance and quality of the patches as well as that of the surrounding environment. The Patch Choice Model predicts that resource patches that provide greater net return rates than the environment as a whole will be included in the diet; conversely, when the net return rate of a resource patch falls below that of the environment as a whole, it is expected that foragers will abandon the patch. The optimal set of resource patches would be those that provide net return rates that are greater than the net return rate of all other available resources within the environment.

Of the three Optimal Foraging Theory models presented here, the Patch Choice Model may be the most difficult to apply to the subsistence data from Bonneville Estates Rockshelter. This is largely due to the fluid nature of resource ranking within the Patch Choice Model. Resource rankings are based on their relative net return rate in comparison to that of the environment as a whole. Factors such as seasonality, environmental changes (e.g., years with increased precipitation or drought conditions), and method of capture (en masse or individually as well as use of technologies such as fish nets or seed beaters) can affect the net return rate for a resource patch and therefore affect the ranking of the patch.

To further complicate the issue, resource patches often occur within resource patches. For example, a marsh may be considered a resource patch, but a school of minnows within the marsh can be considered either as part of the marsh resource patch or as a separate resource patch. If minnows are included in the diet, how do we determine which patch is being exploited, the marsh patch or the minnow patch? The question is one of scale and must be taken into consideration when determining what constitutes a resource patch, especially in archaeological contexts.
In order to determine if the middle and late Holocene occupants of Bonneville Estates Rockshelter were foraging in a manner that corresponds with the predictions of the Patch Choice Model, we would need a fine-grained knowledge of the whole environment within the group’s foraging territory that is currently unavailable. With the data at hand we can only state which resources were exploited but cannot make qualitative statements on whether those resources were within the optimal set of exploitable resources of that environment according to the Patch Choice Model. With that in mind we can still speculate about changes in the subsistence patterns of the middle and late Holocene foragers at Bonneville Estates Rockshelter as a response to changes in the relative ranking of resources.

If we assume that the optimal diet set developed in the previous discussion of diet breadth represents the resource patches available to the occupants of the rockshelter, we can infer that changes in subsistence patterns are related to changes in those resource patches. In the Diet Breadth Model analysis previously discussed, it was concluded that all three cultural components conformed to the first prediction of the model [that is, the highest ranked resource was always included in the diet (in this case pronghorn)] but that the diets of both Cultural Components 5 and 1 did not conform to the second prediction of the model [that resources are added in decreasing order of rank (instead both diets contained high- and low-ranked items but were missing most of the mid-ranked items)] suggesting a decrease in foraging efficiency or sub-optimality in the subsistence strategies of these two components. This is because the Diet Breadth Model treats resource rankings as a non-changing constant and does not account for changes in resource availability as a factor in determining resource rankings.
In the case of the Bonneville Estates Rockshelter, pronghorn is a part of the diet in all three cultural components. According to the Diet Breadth Model this is because pronghorn, by providing a relatively high net return rate, is a high-ranked resource which should always be included in the diet when encountered. Baker (2006:106) states that pronghorn populations are not very susceptible to environmental changes and suggests that in the eastern Great Basin they did not greatly fluctuate during the middle and late Holocene (although see Broughton et al. 2005 for a discussion of an increase in large game populations during this time). If we look at pronghorn populations as a patch resource, we can state that pronghorn was always included in the diet not only because they provide a high net return rate individually, but also because the patch stayed relatively consistent throughout the middle and late Holocene.

We may also look at the absence of mid-ranked resources such as Tansy mustard, bluegrass, and bulrush rhizomes and seeds from the diets of Cultural Components 5 and 1 as changes in the productivity of resource patches as opposed to a decrease in foraging efficiency. Plant resources such as these, as well as lower-ranked resources (e.g., pickleweed and ricegrass), are greatly affected by environmental changes. It may be that resources that are considered low-ranking by the Diet Breadth Model because the individual resource provides a low net return rate were more stable patches during the middle and late Holocene than those resources that are considered mid-ranked by the Diet Breadth Model. That would suggest that stability of resource patches may have played an important role in the foraging decisions made by the Bonneville Estates Rockshelter occupants.
The Central Place Foraging Model

The Central Place Foraging Model is similar to the Patch Choice Model in that it treats resources as patches that are scattered across the landscape. In the Central Place Foraging Model, however it is assumed that resources are collected in logistical forays to patches and brought back to a base camp. Transport costs which include travel time to and from patches become an important factor in determining resource ranking. As transport costs increase, patch ranks decrease. According to Jones and Madsen (1989:530; emphasis in original) “the maximum transport distance (MTD) for any given resource is the distance at which the energy used in gathering and transporting it equals the amount of energy obtained.” As a result, resources will only be transported as far as the net return rate is greater than the costs. Higher ranked resources will be transported farther distances than lower ranked resources, and once transport costs exceed the net return rate for a resource, that resource becomes sub-optimal and should be dropped from the diet.

Barlow and Metcalfe (1996) found that field processing of resources (e.g., the removal of low-utility parts such as hulls, chaff, and stalks at the procurement location) increased their transportability. Central-place foragers, they predict “will spend the amount of time field processing that yields the maximum calories per hour spent travelling to the resource patch, collecting and field processing the resource, and transporting it back to camp” (1996:355). The implication for the archaeological record is that resources should be differentially represented at a site if they are transported. A base camp within a central-place foraging strategy should be archaeologically visible by the absence of low-utility parts of resources indicating field-processing prior to transport.
Field camps, on the other hand, should be archaeologically visible by the presence of these low-utility parts.

If the middle and late Holocene occupants of Bonneville Estates Rockshelter were Central Place Foragers, we would expect to see two things represented in the archaeological data: 1) the presence of extra-local resources that were transported from outside the immediate foraging range of the rockshelter, and 2) evidence of field processing of resources prior to transport. The Central Place Foraging Model also intimates gender-based differences in foraging strategy. However, since biochemical analyses were not included in this study, the gender identity of the originators of the coprolite sample from Bonneville Estates Rockshelter is unknown.

The combined coprolite, faunal, and macrobotanical data from the middle and late Holocene occupations of Bonneville Estates Rockshelter indicates that the occupants exploited a diverse set of resources including pronghorn, jackrabbit, cottontail rabbit, sage grouse, rodents, reptiles, insects, fish, cactus, pickleweed, dropseed, beeweed, goosefoot, shadscale, pinyon pine, bulrush, bluegrass, ricegrass, and other grasses, mustard, goosefoot, cliffbush, maize, and an unknown member of the Solanaceae family. The majority of these resources can be found in a wide range of environments and were likely available in the immediate vicinity of the rockshelter. Some resources, however, such as fish, bulrush, pinyon pine, and pickleweed have much more restricted environments and would likely have been transported to the site either as provisions or through logistical collection forays staged from the rockshelter.

At least four common resources exploited by the middle and late Holocene occupants of Bonneville Estates would had to have been procured from micro-
environments not within the immediate vicinity of the rockshelter. Fish and bulrush are marsh resources and the nearest wetlands are the Blue Lake marshes, which are currently located ~ 6 kilometers east of the rockshelter. Pinyon pine groves are found on the lower elevations of the Great Basin ranges. The nearest pinyon groves would likely have been in the Toano Range ~ 15 km to the west of rockshelter. Pickleweed thrives in extreme alkaline soils and is prevalent along the edges of the Salt Flats. The nearest pickleweed patches would have been located at least 6 km from the rockshelter. The presence of one or more of these resources in each of the three Cultural Components analyzed in this thesis suggests that the middle and late Holocene occupants of Bonneville Estates Rockshelter participated in a subsistence strategy that involved the transportation of resources.

Evidence for field processing of some resources is indicated by the macrobotanical assemblage from the rockshelter. Although pickleweed was apparently a large component of the diet of the Bonneville Estate Rockshelter occupants, there is little evidence that this resource was collected and processed on site. At nearby Danger Cave pickleweed chaff is prevalent in the cultural strata indicating that the resource was collected and processed on site. Pickleweed chaff is present only in small quantities at Bonneville Estates suggesting that the majority of this resource was field-processed prior to being transported to the site. The same argument can be made for pinyon pine. Pine cones are found in small quantities at Bonneville Estates Rockshelter but the prevalence of pinyon pine hulls in Stratum 2 of the rockshelter indicates that this resource was primarily transported to the rockshelter after the nuts were removed from the cones.
The subsistence data from the middle and late Holocene occupations of Bonneville Estates indicates that the occupants participated in a subsistence strategy that involved both the transportation of resources and field-processing of some resources prior to transportation. We can conclude, then, that they behaved in a manner consistent with the Central Place Foraging Model.

Conclusion

This chapter had two goals: 1) to combine the coprolite, faunal, and macrobotanical data from three Cultural Components (5, 3, and 1) at Bonneville Estates Rockshelter to provide a clearer picture of human subsistence strategies at the site during the middle and late Holocene, and 2) to examine those subsistence strategies within the framework of three Optimal Foraging Theory models: Diet Breadth, Patch Choice, and Central Place Foraging.

The result of the combined coprolite, faunal, and macrobotanical data from Bonneville Estates Rockshelter indicates that prehistoric human foragers exploited a diverse set of resources throughout the middle and late Holocene including: pronghorn, jackrabbit, cottontail rabbit, sagegrouse, rodents, fish, reptiles, insects, cactus, pickleweed, dropseed, ricegrass, pinyon pine, shadscale, bluegrass, mustard, cliffbush, bulrush, goosefoot, beeweed, and maize. Some resources such as: large game (artiodactyls and in particular pronghorn), fish, pinyon pine, bulrush, ricegrass, shadscale, and pickleweed exhibit continuity in the diet through time while other resources, such as: jackrabbit, cottontail rabbit, bluegrass, and mustard appear to have had a more transitory position in the diet.
When the combined subsistence data for the middle and late Holocene occupations of Bonneville Estates Rockshelter was compared to the predictions of each of the three Optimal Foraging Theory models, several interesting patterns appeared.

According to the predictions of the Diet Breadth Model, only the diet of Cultural Component 3 occupants could be considered optimal foragers. This is because while the diets of all 3 cultural components contain both the highest and the lowest ranked items in the diet only Cultural Component 3 contains mid-ranked resources. The absence of mid-ranked items from the diets of Cultural Components 5 and 1 indicates that these prehistoric foragers did not include items in the diet in decreasing rank of their order, therefore violating one of the predictions of the Diet Breadth Model. There may be several reasons for this including the absence of these resources in the environment during these occupations, poor preservation, and miscalculation of resource rankings. Further research would be needed to determine if any or all of these factors have contributed to the patterns we see in the Diet Breadth of the middle and late Holocene occupants of Bonneville Estates Rockshelter.

The predictions of the Patch Choice Model were more difficult to verify with the data currently available for the middle and late Holocene occupations of Bonneville Estates Rockshelter. The current analysis of the data at hand, however, suggests that the Patch Choice Model may explain discrepancies seen between the diets of Cultural Components 5 and 1 and the Diet Breadth Model. In the Patch Choice Model resource ranks are fluid and productivity of resource patches play an important role in determining the relative ranking of resources. The absence of so-called mid-ranked resources from the Diet Breadth Model during the Cultural Component 5 and 1 occupations may actually
reflect a lower productivity in those patches and therefore a change in their ranking status from mid- to low-ranked resources. Further research of the paleoenvironment of the area surrounding Bonneville Estates Rockshelter during the middle and late Holocene would be needed to determine if the diets of the occupants correspond to the Patch Choice Model.

The Central Place Foraging Model assumes that foragers travel to and from habitation sites to resource procurement sites. The subsistence data available for the middle and late Holocene occupations of Bonneville Estates Rockshelter indicates that certain resources were transported to the site after some minimal field processing. This suggests that the occupants practiced a foraging strategy consistent with the Central Place Foraging Model.

This analysis concludes that the middle and late Holocene occupants of Bonneville Estates Rockshelter can be considered optimal foragers according to the Central Place Foraging Model. Both the Diet Breadth Model and the Patch Choice Model may also apply to the patterns seen in the diets of the middle and late Holocene occupants; however, additional data about the paleoenvironment within the vicinity of the rockshelter as well as other factors such as site preservation and prehistoric foraging techniques would be needed in order to determine if they could be considered optimal foragers according to the predictions of these models.
Chapter 5: Discussion and Conclusions

The potential of coprolites to provide valuable and unique information concerning the diet and health of prehistoric peoples has been recognized for at least the past 100 years (see Reinhard and Bryant 1992 for a full discussion of the history of coprolite analysis). Early coprolite studies, however, were often perfunctory, and it was not until the second half of the twentieth century that the analysis of coprolites became commonplace in archaeological studies as an important tool in our understanding of prehistoric subsistence (see Callen 1963; Fry 1976, 1980; Heizer 1970; Heizer and Napton 1969; Jenkins 2007; Martin and Sharrock 1964; Minnis 1989; Rhode 2003; Sobolik 1990, 1993; Sutton 1998; Sutton and Reinhard 1995). The arid environment of the American Southwest (and in particular dry caves and rockshelters in the Great Basin) is exceptionally good for preserving organic material, such as coprolites, that would have otherwise deteriorated in more open sites, and several studies have been carried out on coprolites from these types of sites. In this thesis I analyzed a coprolite data set from a rockshelter site (Bonneville Estates Rockshelter) in the eastern Great Basin in an attempt to reconstruct the diet of prehistoric human foragers who occupied the site during the middle and late Holocene. Two other sites in the eastern Great Basin have also provided coprolite data sets; these are Danger Cave and Hogup Cave (Figure 5.1). The following sections present dietary data, as revealed in the analysis of coprolites, from both of these sites and will compare it to the trends seen in the diet of middle and late Holocene foragers at Bonneville Estates Rockshelter. I then conclude this work with a summary of the data presented in this thesis and some suggestions for potential future lines of research.
Danger Cave

Danger Cave is located in the Desert Hills of the Silver Island Range in northeastern Utah. Several excavations of Danger Cave have revealed a fairly continuous human occupation of the site over the last 10,000 years (Fry 1976; Jennings 1957; Rhode
and Madsen 1998). Analysis of the coprolites from this site by Fry (1976) identified pronghorn, insects, bird feathers, shadscale, pickleweed, rabbitbrush, Compositae, dogwood (*Cornus* sp.), prickly pear, phlox (*Phlox* sp.), pine (*Pinus* sp.) seed, and bulrush seed. The coprolite data indicated that the occupants of Danger Cave relied heavily on pronghorn, prickly pear, and pickleweed (although dependence on this resource seems to have diminished over time).

**Hogup Cave**

Hogup Cave is located approximately 80 km northeast of Danger Cave on the western edge of the Hogup Mountains. The occupational history of Hogup Cave is not as long as that of Danger Cave, with the earliest occupation dating to approximately 8,500 to 9,000 years ago (Fry 1976). Fry (1976) also analyzed coprolites from this site pickleweed, Gramineae, maize, pepperweed (*Lepidium* sp.), prickly pear, and bulrush seed. The coprolite data are similar to that from Danger Cave and indicates a heavy reliance on pronghorn, prickly pear, and pickleweed; however, the occupants of Hogup Cave seem to have been slightly more dependent on pickleweed and prickly pear, and less dependent on pronghorn than their neighbors at Danger Cave. Pickleweed also diminishes in importance at Hogup Cave over time.

**Bonneville Estates Rockshelter**

Bonneville Estates Rockshelter is located along the western edge of the Bonneville Basin about 30 km south of Danger Cave and approximately 80 km southwest of Hogup Cave. The occupational history of this site spans at least the last 12,000 years;
however, human coprolites from the site date to between ~8,250 and 500 years ago. The coprolite data from this site is presented in Chapter 3 of this thesis. Identified coprolite components included pronghorn, cactus (most likely prickly pear), pickleweed, dropseed, reptiles, rodents, jackrabbit, cottontail rabbit, insects, bird feathers, fish, shadscale fruit, bulrush rhizome, and the seeds of bluegrass, ricegrass, beeweed, pinyon pine, and Solanaceae. Major dietary components at this site appear to be pronghorn, cactus, pickleweed, and dropseed.

Discussion

The coprolite data from the three sites, Danger Cave, Hogup Cave, and Bonneville Estates Rockshelter, are very similar. At all three sites pickleweed appears to be the primary focus of subsistence activities during the earliest occupations. Over time, however, pickleweed appears to decrease in importance at all three sites. Pronghorn and prickly pear cactus are also major dietary items at all three sites. Slight differences in ecological settings are likely responsible for minor differences seen in the diets at each of these sites. For instance Fry (1976) notes that the ecological setting of Hogup Cave is relatively harsher than that of Danger Cave and is the likely reason that occupants of Hogup Cave appear to be more dependent on pickleweed and prickly pear and slightly less dependent on Pronghorn than are the occupants of Danger Cave. He also notes that the presence of pine nuts at Danger Cave and their absence from Hogup Cave is also the result of slightly different ecological settings. The presence of fish in three of the coprolites from Bonneville Estates Rockshelter and their absence from coprolites at Danger Cave and Hogup Cave is more difficult to interpret as a result of different
ecological settings. It is assumed in this thesis that the fish remains present in the Bonneville Estates Rockshelter coprolites come from the Blue Lake wetlands, which are located 6 km east of the rockshelter. Both Danger Cave and Hogup Cave have relatively closer water sources (a bog at the edge of the salt flats just below Danger Cave and a playa-edge spring located approximately 2 km east of Hogup Cave) than does Bonneville Estates Rockshelter. The reason for the absence of fish remains in the coprolites from Danger and Hogup Caves despite a close proximity to permanent water sources is unknown; however, it may be that this does not represent an absence of fish from the diet but rather differential survivorship of this resource in the human digestive system (Calder 1977). Of course it may be that the water sources near Danger and Hogup Caves could not support a sizeable fish population, and this resource was therefore unavailable to the occupants.

Conclusions and Future Research

As stated in the introductory chapter this thesis has three goals: 1) to present data obtained from an analysis of middle and late Holocene human coprolites from Bonneville Estates Rockshelter, 2) to integrate the coprolite data with data from the faunal and botanical record of Bonneville Estates Rockshelter to interpret the subsistence of the prehistoric occupants, and 3) to examine the subsistence patterns seen at Bonneville Estates Rockshelter within the framework of Optimal Foraging Theory models to determine if the middle and late Holocene occupants were optimal foragers.

Chapter 3 presented data from the analysis of 18 probable human coprolites recovered during excavation of the Holocene deposits from Bonneville Estates
Rockshelter. The coprolites were identified as belonging to three separate Cultural Components (Cultural Component 5, Cultural Component 3, and Cultural Component 1) that span the middle and late Holocene (from ~8250 to 500 calibrated radiocarbon years BP). The coprolite data revealed that all three occupations had diets consisting of primarily dryland desert resources with pronghorn, cactus, and small seeds (in particular pickleweed and dropseed) as the major dietary components. Other identified coprolite components include reptiles, rodents, cottontail rabbit, insects, bird feathers, fish, shadscale fruit, bulrush rhizome, and the seeds of bluegrass, ricegrass, beeweed, pinyon pine, and Solanaceae.

Chapter 4 illustrated the utility of combining multiple data sets (in this case coprolites, faunal, and botanical) from a site when attempting to reconstruct prehistoric subsistence strategies. Data from botanical analysis of hearth features from the three cultural components and faunal material from Cultural Components 5 and 3 were combined with the coprolite data. The combined data indicates that during the middle and late Holocene human foragers occupying Bonneville Estates Rockshelter exploited a variety of resources including: artiodactyls (in particular pronghorn), jackrabbit, cottontail rabbit, sage grouse, insects, fish, rodents, reptiles, cactus, pickleweed, dropseed, beeweed, goosefoot, shadscale, ricegrass, bluegrass, pinyon pine, bulrush, mustard, cliffbush, maize, and Solanaceae.

Chapter 4 also asked the question “Were the middle and late Holocene occupants of Bonneville Estates Rockshelter optimal foragers?” In order to answer this question I used three models of Optimal Foraging Theory: the Diet Breadth model, the Patch-Choice model, and the Central Place Foraging model. I compared the subsistence data
from all three Cultural Components to the predictions of each model. This analysis concluded that while the middle and late Holocene occupants of Bonneville Estates Rockshelter could be considered Central Place Foragers, both the Diet Breadth Model and the Patch Choice Model did not apply to all of the patterns seen in the diet during this period.

The analysis completed herein has revealed several interesting patterns in the diet of the middle and late Holocene occupants of Bonneville Estates Rockshelter as well as the greater eastern Great Basin region. Pronghorn, pickleweed, and prickly pear appear to have been the staple of human foragers in this region throughout the Holocene. Like the rest of the Great Basin, foragers in this region appear to be Central Place Foragers. Several questions were also raised during this analysis. Two of the more interesting questions are: why certain resources are only represented in one type of data set and not others, and why the diets of the middle and late Holocene foragers meet some but not all of the predictions of the Diet Breadth and Patch Choice models. Our understanding of prehistoric subsistence at Bonneville Estates Rockshelter would benefit from further taphonomic research of the faunal and botanical assemblages to determine whether some of the identified resources were actually part of the diet or brought into the rockshelter for purposes other than food (e.g., tools, clothing, shelter) or by vectors other than humans (e.g., wind and burrowing animals). Biochemical analysis of the coprolites could inform about potential gender-specific foraging strategies. Additional research into the caloric utility of resources known to be consumed (e.g., pickleweed) could change our perspective on the inclusion of certain resources in the diet. And detailed information of
the local micro-environments surrounding the rockshelter during the Holocene would allow us to fine-tune predictions about prehistoric subsistence strategies.
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