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## Optimal foraging theory and early Archaic plant use at North Creek Shelter

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OPTIMAL FORAGING THEORY AND EARLY ARCHAIC  
PLANT USE AT NORTH CREEK SHELTER

by

Sara C. Hill

Bachelor of Science  
Weber State University  
2004

A thesis submitted in partial fulfillment  
of the requirements for the

**Masters of Arts Degree in Anthropology  
Department of Anthropology and Ethnic Studies  
College of Liberal Arts**

**Graduate College  
University of Nevada, Las Vegas  
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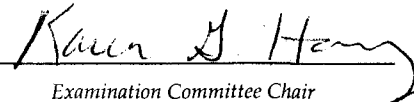
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## ABSTRACT

### **Optimal Foraging Theory and Early Archaic Plant Use at North Creek Shelter**

by

Sara C. Hill

Dr. Karen G. Harry, Examination Committee Chair  
Associate Professor of Anthropology  
University of Nevada, Las Vegas

Optimal Foraging Theory has received considerable intellectual criticism since its use as an archaeological tool for understanding human behavior. In this thesis, I will evaluate Optimal Foraging Theory with an empirical test from North Creek Shelter, an archaeological site located in the Escalante Basin on the northern portion of the Colorado Plateau. This test will focus on plant utilization by the early Archaic occupants of the site. An environmental reconstruction for the Escalante Basin will be used to determine the range and quantity of plant resources available to the early Archaic occupants of North Creek Shelter. Then a botanical assemblage collected during excavation at North Creek Shelter in 2006 will be evaluated in conjunction with the environmental reconstruction to determine the optimality of plant use by the sites early Archaic occupants.

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## CHAPTER 1

### INTRODUCTION

This research addresses fundamental aspects of ecology and subsistence. The project relies primarily on ethnography and a cultural ecology approach, similar to that used by Julian Steward (1938; 1955) in his Great Basin work in which integrated social theory with evolutionary adaptation principles. Steward's 'cultural ecology' approach, which explains culture in terms of interactions that enable and constrain behaviors to the material environment, has a long history in archaeological theory (Steward 1955; Simms 1986; Kelly 1995; Johnson 1999; Winterhalder 2001, Sutton and Anderson 2004). However, archaeological application has often taken ecological approaches to further, attributing all human behavior as a direct function of the physical environment. This approach suggests that knowing the environment is all that is necessary to understand the behavior of its occupants.

In addition to Steward's ecological approach, another is Optimal Foraging Theory. First proposed by ecologists studying foraging behavior in non-human animals (Emlen 1966; MacArthur and Pianka 1966), it has been employed by archaeologists as a model to explain human behavior (Martin 1983; Winterhalder 2001; Douglas and O'Connell 2006). Optimal Foraging Theory states that the environment will determine behavior via optimal exploitation of resources. Optimality is defined by caloric return from resources after subtracting acquisition and processing costs. The higher the net gain the higher rank

the resource and it is expected that the forager will chose the highest ranked resources in a given scenario. Thus, Optimal Foraging Theory is the epitome of environmental determinism.

Emlen (1966: 612) initially alluded to limitations of optimal foraging models, stating that, “no animal has faultless judgment”. However, some archaeologists use the model in a way that implies that humans have faultless judgment and will optimize in all endeavors. To further complicate the model, archaeologists have often assumed that caloric exchange with the environment is the only currency by which behavioral decisions are made.

Unlike Steward’s cultural-environmental interaction model, Optimal Foraging Theory is that it discounts the role of culture in determining human behavior. For example, Bennett (1993) states that values, a moral process, assigned to environmental resources are not determined by nature, but rather through the dynamics of culture. As Bennett points out, subsistence behaviors alone cannot determine a sequence of events, and needs and desires resulting from social living can occur with or without a relationship to the physical environment.

In additional scrutiny, Optimal Foraging Theory has often been used in the analysis of hunter and gatherers in marginal environments because their perceived simple culture is geared toward surviving in harsh environments. However, it is also probable that foragers in a marginal environment have complex social interactions, which may transcend the simplistic hand-to-mouth behaviors (Sassaman 1998). Additional criticisms of the Optimal Foraging Theory model include the assumption that hunter and gatherers operate in the same social dogma as western capitalist society, where it is assumed that

all human behavior is for maximizing social status and economic returns (Shanks and Tilley 1987; also see Shanks and Tilley 1992 and 1996).

The cost/benefit calculations of Optimal Foraging models work well in ranking resource caloric and energy exchanges that may motivate resource acquisition. However, less quantifiable reasons for behavior, such as altruism are elusive to this model. Unfortunately, many researchers have chosen to violate Optimal Foraging Theory's assumption and tried to use Optimal Foraging to account for unquantifiable variables (for overview discussion, Kelly 1995; Johnson 1999). When optimization principles are not found to apply, such researchers tend to interpret these findings not as contradictory to Optimal Foraging Theory, but as giving a quantifiable variable to the indefinable attributes of culture (e.g., Bird and O'Connell 2006). Such an approach enables Optimal Foraging Theory to be preserved as a theoretical paradigm. This is because as a model, misapplication of OFT may not be readily apparent. Elevating the approach to a theoretical paradigm (i.e., a high-range theory) does not mitigate the misapplication; however, it does conceal assumptions.

This research evaluates the conventional use of Optimal Foraging Theory using data from North Creek Shelter. North Creek Shelter is a prehistoric archaeological site located 6 miles west of Escalante, Utah, on the Northern Colorado Plateau. This research examines whether Optimal Foraging Theory, without the violations in the assumption stated above, can explain plant use at North Creek Shelter. The project focuses on plant usage by the early Archaic occupants of the site (approximately 7,500 years ago).

To test Optimal Foraging Theory at North Creek, an environmental reconstruction for the Escalante Basin will be used to determine the range and quantity of plant resources

available to the early Archaic occupants of this site. Then a botanical assemblage collected during excavation at North Creek Shelter in 2006 and 2007 will be evaluated in conjunction with the environmental reconstruction to determine optimality of plant use by the site's early Archaic occupants. North Creek Shelter has continual hunter-gatherer occupational components and intact sediments. Thus, it is a suitable candidate for evaluation of Optimal Foraging Theory. Additionally, the site is significant in its potential to yield information about the prehistory of an area where understanding is currently lacking. Thus, practical and intellectual merit will be satisfied by this research.

## CHAPTER 2

### THEORETICAL RESEARCH BACKGROUND

#### Development of Ecological Approaches

Human ecology broadly addresses human interaction with the environment. This approach is habitually classified as either biological or cultural. Biological ecology stresses adaptation through biological means, whereas cultural ecology emphasizes adaptation through cultural means (Steward 1932, 1941, 1955; see Sutton and Anderson 2004 for overview). Arguably, a combination of the two approaches is both plausible and probable. In practice, the two are seldom integrated.

A fundamental principal in human ecology is evolution, specifically, the concept of adaptation and change. In humans, biology and culture are assumed to be the primary means of adaptation and change. Thus, human ecology logically follows these assumptions.

Because of its emphasis on adaptation, human ecology can be synonymous with human evolutionary ecology. The model is important because human evolutionary ecology differs from previous culture-change models in that it accounts for individual decision making (in the context of both individual and group fitness). This is a major addition to evolutionary research because this model often breaks away from the functional-structural culture-change models. As Gremillion (1997:3) points out, "it does not require faith in the existence of some system- level tendency to strive and maintain an



adaptive equilibrium.” With a waxing discontent of Functional/Structuralism and a desire to emphasize the individual over the group, evolutionary models are appealing to many researchers. Human evolutionary ecology addresses the subject of change over time, in the context of adaptive optimality. This thesis is not as much a look at change through time, which is the goal of much of social theory, rather, it is evaluating a model that is often applied and used to evaluate the change. Only changes in the environment that are associated directly with the model’s evaluation are explored. <sup>1</sup>

Ecological approaches can be classified as Imperialist, Arcadian, and Scientific (Kormondy 1976; Wilson 1967). A theoretically Imperialist approach can be exemplified by Service’s (1971) band, tribe, and chiefdom classifications. These classifications form a hierarchy based on a level of control, or dominion, over fellow humans and the environment. However, when the assumption of dominion is removed, the hierarchy no longer exists and the model fails. Thus, the notion of hierarchy is a fundamental assumption in Imperialistic applications. This has a significant implication if applied to a strictly egalitarian, foraging society where dominion and hierarchy are not present.

In contrast to the Imperialist approach, the Arcadian approach assumes harmony with the environment. It appears to have been developed as a backlash to the imperialistic approach. This model acknowledges cultural relativism and can be exemplified by the perception of the ‘noble savage’ that idealized hunter-gatherers as possessing an idealistically egalitarian, thus moral, relationship with the environment. This approach is utilized by cultural relativists like Franz Boas. Indeed, this model is still popular as it is used in many contemporary and sustainability models.

Of the three approaches, the Scientific is most often used today. This approach started with the Greeks, though the Chinese also had a systematic, thus, scientific approach. However, history favors the Greeks contribution to the Western Tradition. Additionally the Socratic method, to which we derive the modern scientific method, is of Greek origin. The Greeks classified different cultures and assumed them to be the products of their environment –specifically, a product of temperature. “Stupid” people were a product of a cold environment, hot climates produced “lazy” people, and “perfect” people came from warm temperate climates (Sutton and Anderson 2004). Not surprisingly, the Greeks considered themselves the latter. These classifications and assumptions allow for empirical testing of hypotheses, and thus the synchronic scientific approach. We can also attribute the Greek’s approach as the first application of environmental determinism.

#### Julian Steward’s Cultural Ecology

This thesis will rely primarily on a cultural ecological approach, similar to that used by Julian Steward (1938; also see 1955) in his Great Basin ethnographic work, which integrated social-cultural theory with evolutionary adaptation principles. Thus, Steward’s ‘cultural ecology’ is inclusive of cultural and biological evolutionary ecology. Steward’s cultural ecology approach, which explains culture in terms of interactions that enable and constrain behaviors with the material environment, has a long history in archaeological theory (Steward 1955; Johnson 1999). This is particularly true in the arid western United States.

Steward’s theory of cultural ecology, as any theoretical approach, has its critics (e.g., Crum 1999; Walker 1999). However, the paradigm of cultural ecology is an enduring and

unifying component of Great Basin cultural studies. Murphy (1977) suggests that this endurance is partially because it never really was a predominant social theory in anthropology, such as structuralism, and therefore was spared the brunt of intellectual attacks. However, to those who find fault with cultural ecology, “Steward nonetheless did a great service for modern generations by recording what he did” (Fowler et al. 1999: 59). Indeed, this thesis will draw the majority of its theoretical as well as ethnographic data, from Steward’s work.

There are two primary resources used for studying Steward’s cultural ecology model: *Julian Steward in the Great Basin* (Clemmer, Myers, and Rudden 1999). *Evolution and Ecology: Essays on Social Transformation* (Steward 1977), the former is a select compilation of Steward’s work that was published posthumously by Jane Cannon Steward, Julian’s widow, with the help of a former student, Robert F. Murphy.

### Modern Inception of Optimal Foraging in Ecological Models

One of the predominant theoretical approaches used by archaeologists has come from evolutionary ecology, specifically, biological ecology. For the reasons discussed above, evolutionary biological ecology is appealing. Additionally, other themes, such as environmental determinism gained favor beginning in the 1970s as archaeologists sought to be more scientific in their data collection and evaluation. Even though concepts of environmental determinism are seen as far back as ancient Greece, in the 1960s three American biologists contributed to a model of environmental determinism that archaeologists find exceedingly appealing.

In 1966, ecologist J. M. Emlen published “The role of time and energy in food preference” in *American Naturalist*, a popular biology Journal. In that same issue, R. MacArthur and E. R. Pianka published “On the optimal use of a patchy environment.” These two groundbreaking articles revolutionized the biological study of foraging behavior for both non-human and human animals. Specifically, the articles were on the study of non-human foragers and addressed herd/group foraging and predator foraging, respectively.

One of the major advantages of using environmental determinism models such as those by Emlen, MacArthur and Pianka is that they provide statistically valid methods to predict foraging behavior from environmental variables. Conversely, these models can be used to understand the past behavior of foragers, so long as environmental variables can be ascertained. This aspect, not surprisingly is appealing to archaeologists in evaluating past behavior. Though the foraging models were based on non-human foragers, archaeologist took small note and often assumed that non-human and human foragers were analogous. By the 1980s, this model had a prominent place in archaeology. In fact, this model has been elevated to an archaeological theoretical paradigm, which is still widely applied today.

#### Archaeological Applications of Optimal Foraging Theory

For more than 80 years, many archaeologists have interpreted social organization and behavior as influenced by or, in some cases, a directly correlated with the physical environment. At first, the majority of these approaches centered on the idea of cultural ecology as presented by Steward, because this approach allows for culture relativism as a dynamic variable in human decision making.

In the 1970s, archaeology was undergoing a major paradigm shift in its theoretical approaches. Middle-Range theory (Binford 1964, 1967, 1972, 1980, 1983ab, 1987) ushered in both a more systematic and sophisticated approach to archaeological interpretation. Additionally, Binford (1962, 1981) called for archaeologists to be more anthropological in their studies. The combination of these factors produced a scientific approach with the goal of more clearly understanding human behavior. Naturally, the Optimal Foraging Theory and its testable models proposed by Emlem, Pianka and MacArthur were attractive approaches to retrospectively interpret human behavior. By the 1980's, predator/ prey and herd models were liberally applied by archaeologists in an effort to understand past human behavior.

The most fundamental principal of Optimal Foraging (also referred in the literature as Optimal Diet) is cost/benefit analysis. Simply, the exploitation of a resource is beneficial to the collector when the caloric acquisition costs exceed the calories expended to gather and process the resource. On occasion anthropological researchers have deviated from the original model and attempted to replace the caloric and/or acquisition and processing costs with other variables. Specific applications and deviations from the cost/benefit ratio are introduced below and further discussed in Chapters 6 and 7.

Another fundamental principle of Optimal Foraging is resource ranking. Ranking is a function of the cost/benefit outcome. There are several methods for evaluating cost/benefit and subsequent resource ranking. These methods have minor variations but fall into one of two overarching approaches, Dietary Breadth and Linear Programming.

Yet another key concept in Optimal Foraging Theory is the resource patch. Using the assumptions of Optimal Foraging Theory, all researchers use a patch model when

discussing human choice. Patch models come in several varieties, most generally, a patch refers to a foraging area containing multiple resources, though less commonly, a patch refers to a particular resource, e.g. a patch of cacti. A patch has cost/benefit advantages when foragers encounter numerous resources within an excursion, making acquisition of both high to low resources the same, while mitigating risk by incorporating high to low range resources instead of risking pursuit of a high rank resource without guarantee of procurement. Thus, risk is mitigated. However some researchers differentiate further limiting the definition of patch to a particular high-ranked resource patch (Winderhalter 1981; Yesner 1981). This is based on the assumption that the higher ranked resource is the only significant contribution, and thus the only goal for the forager. In both scenarios, the forager moves on once the resource(s) are depleted to the point that it is unable to produce an advantageous cost/benefit ratio.

The dietary breadth model accounts for the total caloric return from an individual and the addition of multiple resources. Its strength is that it provides a predictive behavioral model that accounts for human choice and cultural differences in acquisition pertaining to processing costs. Individual resources return rate is not as important, rather the composite of the total calories collected divided by the total calories expended to collect and process all resources results in a high caloric return rate.

The linear programming model has advantages in some applications because it mitigates deviations from the expectation of cost/benefit exploitation established by the dietary breadth model, thus, upholding the integrity of Optimal Foraging Theory where it may otherwise fall short of explaining human behavior. This is because linear programming accounts for dietary variables other than calories (i.e., fat, carbohydrates,

and vitamin and mineral nutrients). Dietary constraints, for example shortage of a particular nutrient in the forager's environment such as salt or iron, are important in linear programming and its interpretation. In essence, linear programming works well in rationalizing why a resource may be more desirable than its rank defined solely upon caloric exchange.

Another terminology used in Optimal Foraging Theory is herd and predator scenarios. Ecologists have differentiated herd foragers (e.g., deer, schooling fish) versus an individual forager (e.g., cats, birds of prey). The primary difference in these terminologies is the underlying assumption that predator scenarios explain lower ranked resources are only harvested while in pursuit of the highest ranked (i.e., goal) and this is a function of the predator's uncertainties in obtaining the goal. Herd models explain the incorporation of lower ranked resources in terms of overall net gain and/or risk mitigation.

Both herd and predator models have been used to explain non-dietary resource acquisition such as hide procurement (Keen1981). Researchers have also used linear programming to attempt to explain deviation from the expectations of the dietary breadth model in terms of storage/risk mitigation, social signaling, and other cultural motivations. It should be noted that linear programming is designed for quantifiable nutritional properties; using it to interpret social motivation is an arguably inappropriate application of linear programming. In such instances, linear programming is used as a high range theory without the methodological use of a linear quantitative model.

## Critiques of Optimal Foraging Theory in Archaeology

The year 1983 produced two publications evaluating the theoretical premise and application of Optimal Foraging Theory; “Optimal Foraging Theory: A Review of Some Models”, published in *American Antiquity* (Martin 1983), and “Anthropological Applications of Foraging Theory: A Critical Review”, published in *Current Anthropology* (Smith 1983).

Martin’s review is based on Winderhaler and Smiths’ (1981) book *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*. Essentially Martin takes Winderhaler and Smiths’ examples and applies a critique of their Optimal Foraging applications. Additionally, Martin comments on the many inconsistencies in application of Optimal Foraging Theory. He concludes that based on the examples provided by Winderhaler and Smith’s book, inconsistency in application and execution of the model make Optimal Foraging Theory’s lofty goals unattainable. Thus, Optimal Foraging Theory holds little relevance or validity in evaluating human behavior. In short, Martin is the first to criticize analysts for researching high-range theoretical ideals that are unattainable by the methodology of Optimal Foraging Theory.

Smith’s article and its reviews are a foundation and a core for understanding current application of Optimal Foraging Theory. Due to the prominence of *Current Anthropology* and its practice of concurrently publishing article reviews, Smith’s article set a forum for discussion and comment. These critiques and comments are the stepping-off point for which subsequent researchers make their arguments for or against Optimal Foraging.

Smith, like many other researchers, confuses Julian Steward’s Cultural Ecology as being synonymous with ecological determinism. Smith (1983:625) states specifically



that Steward and others with and ecological approaches “cope with only the most rudimentary fashion” aspects of human behavior choices. In fact, Steward was not an environmental determinist and never endorsed Optimal Foraging Theory. Cultural ecology is more in line with more contemporary theoretical views that culture plays the most significant factor in determining human behavior within any given environmental setting.

Unlike the fundamental oversights mentioned above, most contemporary criticism of Optimal Foraging Theory and ecological models as a whole are based on the rejection of Darwinian evolutionary assumptions. These assumptions, ironically, are what make the model appealing to archeologists in the first place. The most significant of these criticisms come from Shanks and Tilley (1987, 1992, 1996), who have published numerous rejections of evolutionary and ecological models. Shanks and Tilley (1987, and references therein) have additionally made related rejections of such concepts as materialism, which, is also associated with the application of Optimal Foraging Theory. The argument is mainly directed at the application of western values onto the variables used to assess choices made by non-western groups. For example, the western values of time versus caloric return, so intrinsic in materialist ecological approaches and specifically Optimal Foraging Theory, are often cited for being Western-biased.

Sassaman (1998) adds the critique that choices and their resulting actions have moral weight that transcend cost/benefit models. Optimal Foraging Theory, beyond the assumption of universal western values, uses empirical measurements that may not be appropriate in interpreting a physical act that is based on such moral values. In short, the evolutionary ecological models do not sufficiently account for social variables for which

there are no quantifiable measurements. For discussion and critique on the application of western values in broad archeological context, see Kelly (1995) and Johnson (1999).

These criticisms have rational merit. Sassaman's argument is particularly compelling. If Optimal Foraging Theory can only be applied to quantifiable variables, can it assume to account for the actions derived from moral values with a quantifiable variable—particularly in small egalitarian foraging groups? This thesis will evaluate whether such limitations affect the legitimate application of OFT in archaeological contexts.

Contemporary proponents of Optimal Foraging Theory have largely ignored these most recent criticisms. Instead, they focus on addressing the issues put forth by Smith (1993) and Martin (1993), in essence many proponents address and attempt to quantify (and justify quantifying) social variables to provide explanation for behaviors that do not follow the dietary breadth or linear programming models. These explanations fall into three categories and are theoretically based on principals of evolutionary reproductive success: these are, “showoff”, risk mitigation, and altruistic explanations for exploitation of costly resources (see Winterhalder 2005 for and overview).

The “show-off” (or costly-signaling) model explains that disproportionately costly resources will be exploited by male hunters to signal reproductive fitness and/or call attention to themselves, thus improving their chances of reproductive opportunities (Smith 2000, Bliege and Bird 2000, Hawks 1993). Risk mitigation explains that storage or social reciprocity may contribute to overall reproductive success through survival of offspring (Ziker 1998, Bliege, Bird and Bird 1997, Winterhalder 1996 and 1990, Kaplan and Hill 1985). Similarly, the altruistic explanation explains that parents and related

individuals may behave in ways that benefit the group and survival of its offspring, thus improving the group's reproductive success (Kaplan and Hill 1993, Betzing and Turke 1986). These categories, and the few exceptions to them, will be discussed further and evaluated in Chapter 7 of this thesis.

### Note

1. Collaboration is underway among North Creek Shelter researchers to specifically address aspects of subsistence change through time at the Shelter. The results are expected to be published in appropriate peer-reviewed journals.

## CHAPTER 3

### THE STUDY AREA ENVIRONMENTAL BACKGROUND

#### Introduction and Geographical Location

This thesis focuses on human adaptations at the end of the Pleistocene/Holocene transition (i.e., approximately 8000 ybp). Using climatic information for this time frame, a list of the botanicals that would likely have been available to the early Archaic inhabitants at North Creek Shelter has been compiled. This information will be critical in making inferences concerning which plants may have been used by indigenous peoples during this time.

North Creek Shelter is located in the Escalante Basin of the Colorado Plateau (Figure 1). Culturally and ecologically, from prehistoric times to the present, this area is a transition zone between the Southwest and Great Basin. The transition of overlapping ecological and biota zones has produced a tremendous array of floral and faunal diversity. This is primarily due to varying precipitation in conjunction with the varied topographical terrain. There are few places in the world where there are more diverse plant dispersions in such a small area (Rhode 2002). Of all the plant variety in the Greater Utah area, over eighty-seven percent of plant species can be found within the Grand Staircase-Escalante Monument (Geib 2001). The Monument also contains eleven species of flora unique to the area (Geib 2001; Belnap 1989).

## Geographical Formation

The geology of the northern Colorado Plateau is comprised primarily of sedimentary rock deposited over the past 256 million years (Geib 2001). The exception is the Aquarius Plateau, which was formed via volcanic processes (Janetski 2007, after Doelling et al. 2000).

The larger Escalante area is composed of several small plateaus that rise above the Escalante desert. These most notably include the Aquarius, Kaiparowits, and Table Cliff. The sedimentary plateaus and volcanic formations are sometimes folded or benched. Erosion from the Escalante and Colorado Rivers, including their lesser tributaries, has removed the softer sediments from these folds and benches and left the harder rock. The result of this erosion has formed the present step-cliff topography (Geib 2001). The eroded lowlands form a significant contrast with the ridgelines and cliffs of the plateaus. There are inexhaustible canyons and terraces because of these highpoints and the many river valleys.

The Escalante valley is geologically associated with the Morrison Formation parent-stone. Morrison Formation comprises the lowest levels and is covered by the subsequent Dakota sandstone formations. The Morrison Formation contains abundant petrified wood, a common tool stone used by indigenous peoples (Janetski 2007). Other popular tool stones obtained from local bedrock formations are Cannon Peak and Paradise chert from the Kaiparowits Plateau and Boulder jasper from the Boulder Mountains (Janetski 2007; Geib 2001).

North Creek Shelter is located just west of the town of Escalante, Utah (Figure 2), at the western end of the Escalante valley. The valley is a small drainage basin formed by the surrounding highland to the north, west, and southeast (Janetski 2007).

The rock shelter is located at the base of a south-facing Dakota Sandstone overhang, at an elevation of 6150 ft (1875 m). Three perennial creeks flow within a quarter mile (under a half a kilometer) of the site. These creeks have carved ravines that run by the site, on route to a juncture into the Escalante River (Janetski unpublished 2005; 2007). The creeks and Escalante River experience drastic variation in flow, both seasonally and in conjunction with the individual precipitation events. The results are both cut and overflow banks.

It is likely that the deposition from stream sediments may have contributed to the stratigraphy at the site. A total of approximately 2.5 meters of sediments have been deposited at the site since the early Holocene, approximately 11,000 years ago. Sediments of 1.5 meters were deposited over approximately 2000 years of the early Holocene. Subsequently, from the mid-Holocene into the Archaic, deposits for the last 9000 years approached only 1 meter (Janetski 2007). The lower levels not only had faster deposition, they show characteristics of darker and more culturally rich sediments along with evidence of periodic ponding and drying (Janetski 2007). This type of deposition may be associated with the seasonal flooding of the nearby creeks, or perhaps these sediments are largely a consequence of colluvial processes when the site was flooded by rain water coming off the cliff via cracks just to the west of the immediate occupation area. These processes would have been more active during the wetter, very early Holocene.

In contrast, the later deposits, laid down during the periods of occupation by the Archaic and Fremont peoples, contain more rock and anthropogenic staining due to slower deposition due to the drier climate of the mid-Holocene. Sediment structure is masked by human and rodent disturbance, but likely sediment origin was still primarily from alluvial debris flow.

North Creek Shelter is located in a transition area between several ecological zones; within 25 miles (40 km) from the site there are mountain elevations over 9850 feet (3000 m) and lowland desert elevations of less than 4590 feet (1400 m) (Yoder 2006; Geib 2001). The site sits approximately mid-elevation relative to the valley floor and has excellent visibility in most directions. Specifically, east, west, and south are visible from the habitation site, and a short walk to the top of the associated sand stone cliff gives a 360 degree vista. In addition to the advantageous vista, it is worth noting that the south facing aspect of the cliff provides a passive solar advantage in the winter and spring.

#### Climate Chronology

The Escalante region, as part of the northern Colorado Plateau, can be broadly defined as upland or cold desert biota. This is somewhat simplistic when considering the vast elevation changes combined with the topographical changes that comprise this area. In essence, microclimates *do* and *did* exist on the Plateau. This is especially true of the Escalante Basin. The prolific presence of diverse microbiotic communities was certainly a factor in subsistence strategies during the terminal Pleistocene. Indigenous hunter-gatherers of the region would have known and exploited plants from these microenvironments.



Although there is little information to assess terminal Pleistocene environments in the Escalante basin, there is some knowledge of climatic trends. The area probably experienced cooler temperatures and greater annual rainfall than today (Madsen 2005; Thompson 1993; Mehringer 1986). However, the rainfall was probably less predictable than the current precipitation cycles. Woody plants such as aspen may have a tolerance for the variability in precipitation and would benefit from the cooler temperatures. This suggests that these vegetative communities may have been lower in elevation than presently observed. The major difference would be that pinyon and juniper, as well as ponderosa communities, would have been few and far between and possibly non-existent in the region. The lower alpine biota would have edged out much of the Pinyon Juniper belt, particularly Pinyon. Thus, with the exceptions just noted, the plants that are available in the region today were similarly available to the indigenous people during the terminal Pleistocene.

### Environmental Setting and Anthropological Implications

The notion that biotic communities are primarily a function of elevation is clearly demonstrated in the Escalante Basin. The Escalante's wide range in elevation ( $\approx$  4500-10000 ft) produces a rich array of biotic resources within the basin. This allows inhabitants, non-human and human alike, a wide access to resources from any elevation within one day's travel.

#### Flora

Presently, the Escalante valley supports the flora and fauna of the Upper Sonoran desert. The valley is characterized by grasses, sage and other chenopods, and patches of

cacti on the flat lands. Higher elevations are composed of Pinyon Juniper, with pockets of Scrub and Gamble Oak, and Douglass Fir. At the highest elevations, stands of Ponderosa Pine, Aspen, and Blue Spruce are supported. Drainages, such as the Escalante River additionally support these and other woody plants such as Willow, Wild rose, and Wolfberry. Although stands of Russian Olive and Tamarisk also grow along the drainages today, they are invasive and would not have been present in prehistoric times.

The following plants would have been available in the area. These orders primarily follow Fowler (1986) and Rhode (2002) (Table 1). Other useful resources include tables compiled by Brown and Lowe (1980) for the Southwest and Geib's table (2001: 36) for the Kaiparowits Plateau (adjacent and to the southeast of the Escalate Basin). The table below includes commonly used ethnographic plants. However, the anthropological implications and in-depth ethnographic treatment of this list will follow in the discussion and results portions of this thesis.

TABLE 1 IMPORTANT SUBSISTENCE PLANTS	
COMMON NAME	SCIENTIFIC NAME
Agave Family	<i>Agavaceae</i>
Utah Agave	<i>A. utahensis</i>
Dail yucca or Banana Yucca	<i>Yucca Baccata</i>
Soaptree yucca	<i>Yucca utahensis</i>
Amaranth Family	<i>Amaranthaceae</i>
Amaranth	<i>A. albus</i>
Pigweed - Amaranth	<i>Amaranthus graecizans</i>
Sumac Family	<i>Anacardiaceae</i>
Smooth sumac	<i>Rhus gabra</i>
Parsley Family	<i>Apiaceae</i>
Apiaceae	<i>Cymopterus newberryi</i>
Carruth sagebrush	<i>Agoseris carruthii</i>
Tarragon	<i>Agoseris Ludoviciana</i>
Big Sagebrush	<i>Agoseris tridentata</i>
Arrowhead balsamroot	<i>Balsamorhiza hirsuta</i>
Sunflower	<i>Helianthus annuus</i>
Sunflower	<i>Helianthus petiolaris</i>
Showy goldeneye	<i>Viguiera multiflora</i>
Barberry Family	<i>Barberidaceae</i>
Fremont barberry	<i>Barberis fremontii</i>
Mustard Family	<i>Brassicaceae</i>
Tansy mustard	<i>Descurainia pinnata</i> var. <i>filipes</i>
Desert pepperweed	<i>Lepidium fremontii</i>
Yellow Crest	<i>Rorippa curvisiliqua</i>
Tumble mustard	<i>Sisymbrium sophia</i>
Desert prince's plume	<i>Stanleya pinnata</i>
Cactus Family	<i>Cactaceae</i>
Echinocactus	<i>Echinocactus lecontei</i>
Echinocactus	<i>Echinocactus mahavensis</i>
Cottontop echinocactus	<i>Echinocactus polycephalus</i>
Cottontop echinocactus	<i>Echinocereus engelmanni</i>
Mammillaria	<i>Mammillaria tetrancistra</i>
Mammillaria	<i>Neolloydia johnsoni</i>
Prickly pear	<i>Opuntia</i> sp.
Prickly pear	<i>Opuntia polycantha</i>
Prickly pear	<i>Opuntia whipplei</i>
Honeysuckle Family	<i>Caprifoliaceae</i>
Honeysuckle	<i>Sambucus raseemoscea</i>

Chenopod Family	<i>Chenopodiaceae</i>
Iodine bush	<i>Allenrolfea occidentalis</i>
Fourwing saltbush	<i>Allenrolfea canesceus</i>
Shadescale	<i>Allenrolfea confertiolia</i>
Big Saltbush	<i>Allenrolfea lentifornis &amp; powellii</i>
Goosefoot Sub-family	<i>Chenopodium</i>
Fremont goosefoot	<i>Chenopodium fremontii</i>
Fremont goosefoot	<i>Chenopodium incanum</i>
Slimleaf goosefoot	<i>Chenopodium leptophyllum</i>
Black greasewood	<i>Sarcobactus vermiculatus</i>
Seablite	<i>Suaeda diffusa</i>
Bush seepweed	<i>Suaeda torreyana</i>
Gourd Family	<i>Cucurbitaceae</i>
Calabazilla	<i>Cucurbita foetidissima</i>
Sedge Family	<i>Cyperaceae</i>
Tule bulrush	<i>Scirpus acutus</i>
Alkali bulrush	<i>Scirpus maritimus</i>
Oleaster Family	<i>Eleaginaceae</i>
Silver buffaloberry	<i>Shepherdia argentea</i>
Health Family	<i>Ericaceae</i>
Greenleaf manzanita	<i>Arcrostaphylos pringlei</i>
Pointleaf manzanita	<i>Arcrostaphylos pungens</i>
Pea Family	<i>Fabaceae</i>
Mesquite	<i>Prosopis glandulosa</i>
Mesquite	<i>Prosopis glandulosa var. torreyana</i>
Screwbean	<i>Prosopis pubescens</i>
Beaverhead Scurfpea	<i>Psoralea castorea</i>
Skunktop scurfpea	<i>Psoralea mephitica</i>
New Mexico locust	<i>Robinia neomexicana</i>
Beech Family	<i>Fagaceae</i>
Gambel Oak	<i>Quercus gambelii</i>
Iris Family	<i>Iridaceae</i>
Rocky mountain iris	<i>Iris missouriensis</i>
Lily Family	<i>Liliaceae</i>
Weakstem Mariposa	<i>Calochortus flexuosus</i>
Smoky mariposa lily	<i>Calochortus leichitlinii</i>
Sego lily	<i>Calochortus nuttallii</i>
Purplespot fritillary	<i>Fritillaria atropurpurea</i>
Blazing Star Family	<i>Loasaceae</i>
White stem blazing star	<i>Mentzelia affinis &amp; dispersa</i>
Desert blazing star	<i>Mentzelia multiflora</i>

Loosestrife Family	<i>Lythraceae</i>
Purple ammania	<i>Ammannia coccinea</i>
Mallow Family	<i>Malvaceae</i>
Glove mallow	<i>Sphaeralceae parvifolia</i>
Broomrape Family	<i>Orobanchaceae</i>
Broomrape	<i>orbanche spp.</i>
Grass Family (Poaceae)	<i>Poaceae</i>
Great Basin wild rye	<i>Echinochloa cinereus</i>
Scratch grass	<i>Muhlenbergia asperifolia</i>
Scratch grass	<i>Muhlenbergia rigens</i>
Indian Ricegrass	<i>Oryzopsis hymenoides</i>
Dropseed	<i>Sporobolus spp.</i>
Purslane Family	<i>Portulacaceae</i>
Lance leaf spring beauty	<i>Claytonia lanceolata</i>
Bitterroot lewisia	<i>Lewisisa rediviva</i>
Rose Family	<i>Rosaceae</i>
Saskatoon serviceberry	<i>Amelanchier alnifolia</i> var. <i>alnifolia</i>
Western chokecherry	<i>Prunus virginiana</i>
Sandalwood Family	<i>Santalaceae</i>
Bastard toadflax	<i>Comandra Pallida</i>
Saxifrage Family	<i>Saxifragaceae</i>
Golden currant	<i>Ribes aureum</i>
Nightshade Family	<i>Solanaceae</i>
Anderson wolfberry	<i>Lycium andersonii</i>
Desert & Coyote Tobacco	<i>Nicotiana obiusifolia &amp; attenuata</i>
Cattail Family	<i>Tryphaceae</i>
Cattail	<i>Typha domingengensis</i>
Common cattail	<i>Typha latifolia</i>
Valerian Family	<i>Valerianaceae</i>
Edible Valerian	<i>Valeriana edulis</i>
Verbena Family	<i>Verbenaceae</i>
Bigract verbena	<i>Verbena bracteata</i>
Grape Family	<i>Vitaceae</i>
Canyon grape	<i>Vitris arizonica</i>

## Fauna

Although this thesis evaluates Optimal Foraging Theory only in reference to floral resources, faunal resources additionally played an important role in prehistoric lifeways. Faunal analysis is concurrently being conducted on the North Creek assemblage, thus it is not yet available for this study (see Avenues for Future Research in Chapter 7).

The fauna we now see in the region can roughly be assumed to be the same since the Holocene forward. During the Pleistocene, mega-fauna, such as bison, mammoth, and camel, dominated the landscape of western North America. These species were important to the Paleo-Indian inhabitants of the Colorado Plateau. However, during the terminal Pleistocene/Early Holocene transition, these large mega-fauna became extinct. Smaller, more broad-range adaptations can be seen in the fauna of this region after the Pleistocene/Early Holocene transition.

The range of present fauna is supported by the flora in combination with the region's topography. In essence, the finger ridges and drainages allow large game such as Mountain Sheep, Elk, Pronghorn and Mule deer to transverse from lowlands to highlands throughout the year. Springs and marshy lowlands support various water fowl. The grasslands support small game such as Cottontail rabbits, Jackrabbits, Squirrels, Rats, and game birds. These are just a few of the significant local fauna since the early Holocene. For an in-depth overview see Geib et.al (2001: 32-33), from which the following table has been adapted (Table 2).

TABLE 2 IMPORTANT REGIONAL ANIMALS	
COMMON NAME	SCIENTIFIC NAME
Bat	Vespertilionidae or Molossidae
Bull Snake	<i>Pituophis melanoleucus</i>
Burrowing Owl	<i>Spteotyto cunicularia</i>
Canyon Wren	<i>Catherpeus mexicanus</i>
Chipmunk	<i>Tamias</i> spp.
Clark's Nutcracker	<i>Nutcifraga Columbiana</i>
Common Nighthawk	<i>Chordeiles minor</i>
Common Raven	<i>Corvus corax</i>
Cottontail Rabbit	<i>Sylvilagus</i> spp.
Coyote	<i>Canis laterans</i>
Desert Bighorn Sheep	<i>Ovis canadensis nelsoni</i>
Eagle	<i>Haliaeetus leucocephalus</i> or <i>Aquila chrysaetos</i>
Flicker	<i>Colaptes auratus</i>
Fox	Canidae
Gambel's Quail	<i>Callipepla gambelii</i>
Great Horned Owl	<i>Bubo virginiaus</i>
Ground Squirrel	Sciuridae
Hawk	Accipitridae
Horned Lizard	<i>Phrynosoma</i> spp.
Hummingbird	<i>Archilochus alexandri</i> or <i>Selasphors</i>
Jackrabbit	<i>Lepus</i> spp.
Kingsnake	<i>Lampropeltis</i> spp.
Lizard	Iguanidae
Mountain Lion	<i>Felis concolor</i>
Morning Dove	<i>Zenaida macroura</i>
Mouse	Heteromyidae, Cricetidae, or Muridae
Mule Deer	<i>Odocoileus hemionus</i>
Ord's Kangaroo Rat	<i>Dipodomys ordii</i>
Pronghorn Antelope	<i>Antilocarpa Americana</i>
Owl	Strigidae
Pinyon Jay	<i>Gymnorhinus cyanocephalus</i>
Rattlesnake	<i>Crotalus</i> spp.
Red-tailed Hawk	<i>Buteo jamaicensis</i>
Rock Wren	<i>Salpinctes obsoletes</i>
Skunk	<i>Spilogale gracilis</i> or <i>Ephitis mephitis</i>

## CHAPTER 4

### THE STUDY AREA CULTURAL BACKGROUND

#### Introduction

The majority of what is known about the prehistory of the Escalante region is a result of the few archaeological excavations that have taken place in this area. Archaeological survey has also provided information. Another unfortunate fact is that no early ethnographers were interested in this area. Thus, we have no substantial early contact ethnographic accounts. We are left to rely on the unreliable accounts of explorers and the ethnographic work of surrounding areas, such as those by Isabel Kelly (1906) and Julian Steward (1932) on adjacent Southern Paiute groups.

The most extensive archaeological research in the area resulted from the relatively recent cultural impact surveys and mitigation in response to federally-legislated Section 106 projects. Most of this research has been conducted by Phil Geib, who then worked for the Navajo Nation Archaeological Department (NNAD). Geib's research resulted in numerous monographs and publications about the archaeology of the Escalante and Kaiparowits Plateau regions (Geib and Spurr 2002; Geib et al. 2001; Geib 1995, 1996; Geib and Davison 1994). As a result of these studies, we now know that throughout most of the area's history, the region was used primarily as hunting and presumably gathering ground (Geib et al. 2001). The exception was the Fremont tradition (intermittently,



approximately 2000-700 BP) when areas were used for dry farming (Geib et al. 2001). The chronology used below is largely a result of Geib's work.

### Culture Chronology and Archaeological Background

The culture history for the Escalante region generally follows that of other areas of the Colorado Plateau and lower Great Basin, though dates may vary slightly between regions. Its culture history is roughly divided into six periods: Paleoindian, Archaic, Early Agricultural, Formative, Post-Formative, and Euro-American (Geib et al, 2001). The first evidence of human occupation in the Colorado Plateau is dated to 11,500 BP. (Adovasio and Peddler 2004; Grayson and Meltzer 2002; Haynes 2002), dates which are based on the recovery of Clovis, Folsom and late Paleoindian points from ground surface context (for overview see Smiley 2002). North Creek Shelter at 9990 BP is the earliest site to be investigated on the Colorado Plateau. Paleoindian people were highly mobile and to have subsisted on big game hunting. Evidence of the exploitation of extinct megafauna, such as mammoth, paleobison, paleo horse and camel, have been found throughout the western United States (Jennings 1980).

Although the transition dates are debated, it appears that after the Terminal Pleistocene/ Early Holocene transition, approximately 9,000 rcy BP., most of the megafauna became extinct. This was likely due to environmental change that disrupted the rich grassland cycles. A new pattern of a cooler and wetter climate has been proposed by Grayson (1993, 2002), Madsen (2002), and Wigand and Rhode (2002). The indigenous peoples appear to have adapted to this change by adopting a more broad-based subsistence pattern (Madsen 2005). This strategy involved exploiting more plant and smaller mammal resources. The research for this thesis is focused on the early Archaic

(approximately 7,500 BP) occupation of the site, thus, placing it after the Terminal Pleistocene and into the Holocene subsistence adaptations.

The transitional nature of the Colorado Plateau's location between the Anasazi and Great Basin Paiute groups have also encouraged researchers to 'pluck and pull' culture chronological terminology. The Escalante region sites with agricultural components are most often categorized using the Anasazi Pecos classification, (i.e., Pueblo I, II, and III; AD 750-900, AD 900-1150, AD 1150-1350, respectively). Additionally, many of the earlier recorded sites were labeled with the Pecos classification if pottery was present, without regard to the presence or absence of Anasazi characteristics.

Presently it is known that the classification in this area is more complicated than the Pecos classification, and for that matter, the Paleoindian, Archaic, and Formative classifications. True to the ecological integration of this area, the inhabitants often leave evidence of material culture that is not entirely Southwest or Great Basin. Currently most researchers consider the area culturally Great Basin, with the addition of a very few infused material culture items from the Southwest. Thus, researchers in the area have moved away from using the Pecos Classification system for the region. Though not as helpful for subsistence indicators, Anasazi classifications are useful for assigning time frames to some pottery traditions in the region. This may indicate the chronology of trade networks, or perhaps, less likely, migration to and from the region.

Cultural remains associated with the poorly understood Fremont are also often found in the area. Although this culture remains are not well defined (though see Madsen 1989 and Madsen and Simms 1998 for an overview), they are best characterized as being somewhere along the continuum between the extremes of highly mobile foragers and

settled maize farmers (Madsen 1982, 1989; Madsen and Simms 1998; Simms 1986, 1996).

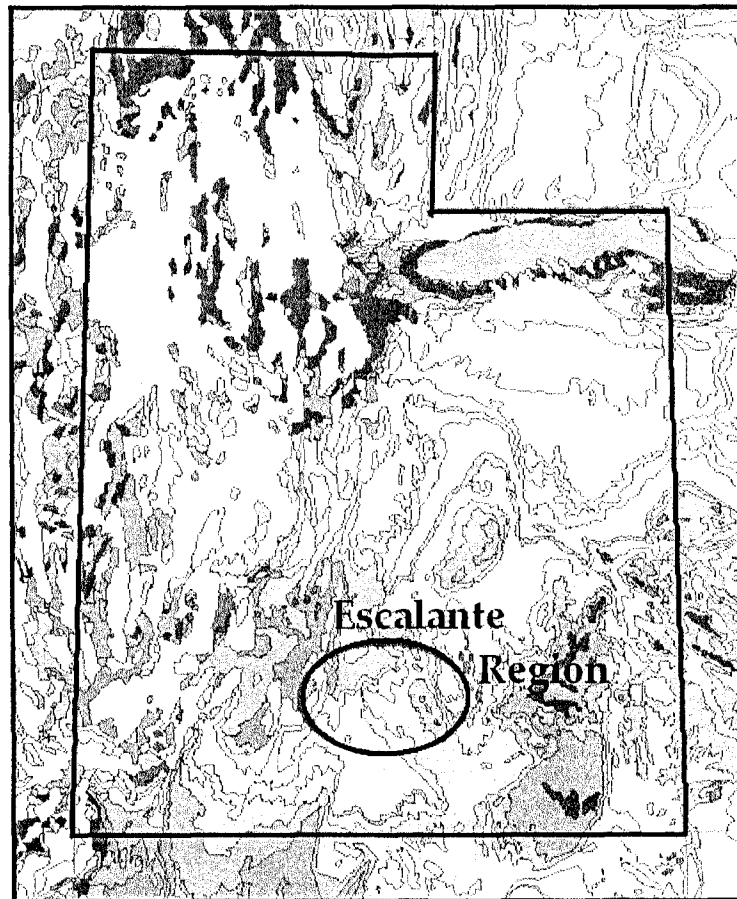


Figure 1: The Escalante Region

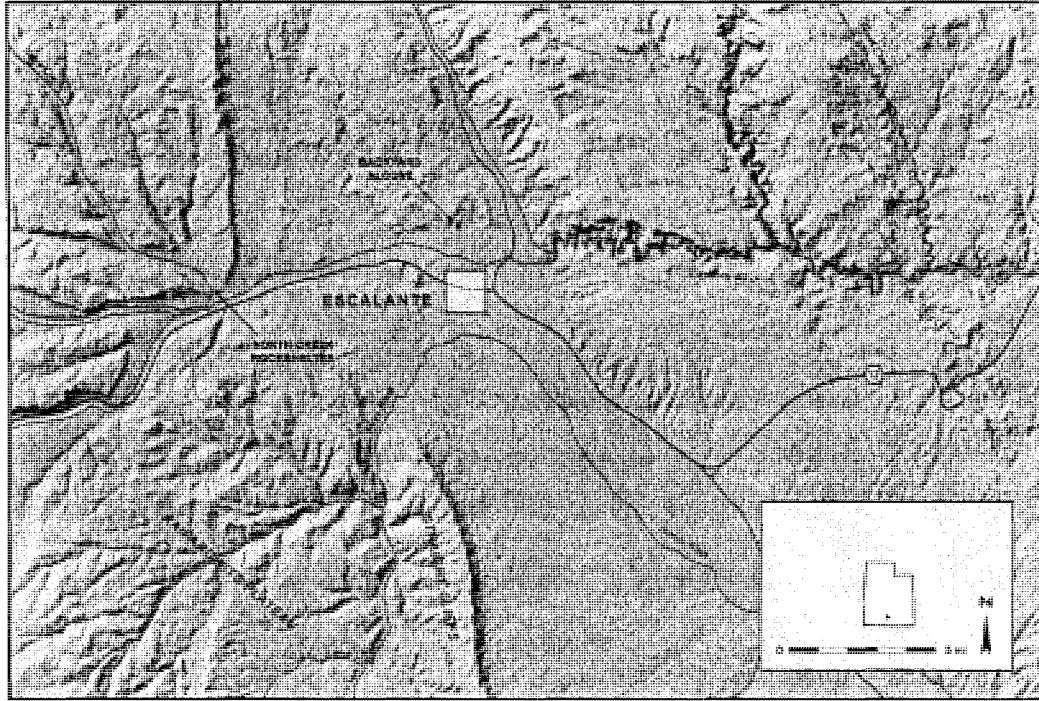


Figure 2: North Creek Shelter location (Janetski et al. 2006).

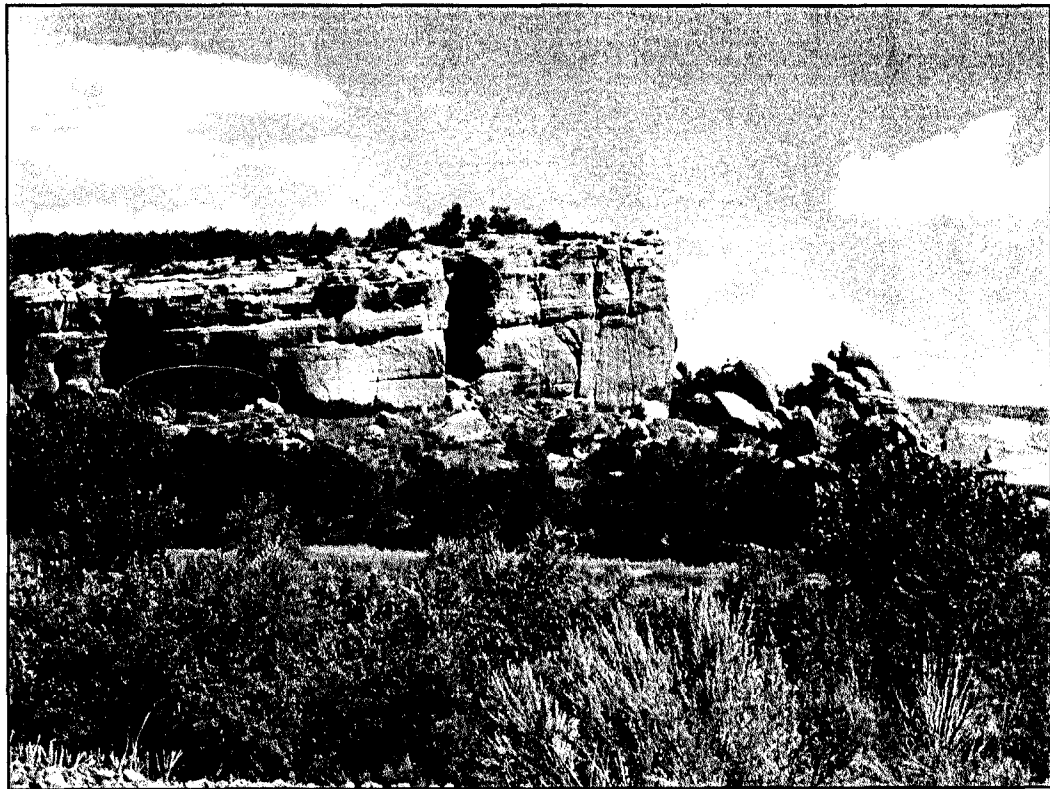


Figure 3: Photograph of North Creek Shelter, site area indicated by ellipse  
North Creek Shelter (Hill 2007).

The first archaeological work at North Creek Shelter was conducted in 2004, under the direction of Dr. Joel Janetski of Brigham Young University. Since then, Dr. Janetski and a small crew have returned every summer (up to present, 2008) for subsequent investigations. Archaeological work in 2004 consisted of excavating a 1x1 x 2.14 m deep test pit, from which it was determined that the site had considerable cultural deposits and time depth. In 2005, the test pit was expanded to six cubic meters and in some places was excavated to as much as 2.54 m below ground surface (Janetski 2005). This grid was again expanded in 2006, to excavate a total of twenty-six cubic meters of soil, and in some units to a depth of over 3 m (Janetski et al. 2006). Information collected from these excavations show a repetitive use of North Creek Shelter from Paleo-Indian time forward. Geological stratigraphy, as well as radiocarbon dating, place the earliest human occupants at North Creek Shelter at 11,260-11,420 yrs B.P. (2 sigma calibration) (Table 3, Janetski 2008).

From the first investigations of North Creek Shelter it was readily apparent the site has substantial potential to substantial yield information about the prehistory of the Escalante Valley, northern Colorado Plateau, and the larger Great Basin. It is the oldest known site on the northern portion of the Colorado Plateau, and one of the most well-preserved sites in the Great Basin. Excavation recovery shows a sequence that includes Paleo-Indian Archaic, Formative, and Protohistoric foragers, as well as historic Anglo cultural traditions, respectively. In addition, the site appears to have been occupied continuously up to Protohistoric times, with the exception of a little understood hiatus during the middle Archaic period (for overview see Geib 1996, Janetski 2005, 2008). This hiatus is indicative of many sites in the area; however there are many other sites that

were occupied during this time. Further research is needed to make solid inferences concerning the occurrence of shifting site occupation during this time.

Other Great Basin cave and shelter sites with good organic preservation have yielded much information on prehistoric subsistence practices in terms of material culture. However, most were excavated in the early to mid 1900s, before new archaeological methods and technologies were developed. Specifically, no microbotanical and few macrobotanical samples were collected in these excavations. The exceptions to this pattern are sites excavated by Rhode (2002) and Belnap (1989). Using new methods for analyses of botanical remains, we are able to address issues such as environmental characteristics and site occupation patterns (Madsen 2005; Rhode 2002; and Thompson et al. 1993).

TABLE 3  
RADIOCARBON DATES FROM NORTH CREEK SHELTER  
(adapted from Janetskie 2007)

Beta No.	Stratum	Material	Depth	Conventional. Radiocarbon BP age	2 Sigma cal. BP age
197358	Vd	Maize	~65	940 $\pm$ 40	769-940
221411	VI	Slab-lined hearth, Maize	~65	1050 $\pm$ 40	920-1050
221414	V	Pooled Juniperus & Pinus charcaol	~75	6020 $\pm$ 60	7000-6710
221412	IV	Various pooled charcoal	~120	7670 $\pm$ 80	8600-8350
207167	IVI	Hearth, pooled Juniperus	~130	7970 $\pm$ 80	9030-8590
210253	IVI	Pit, Pooled Juniperus & Pinus Charcoal	~155	8320 $\pm$ 120	9530-9010
197359	IVi	Pooled charcoal	~160	8310 $\pm$ 70	9490-9100
194030	Ivb	Pooled Pinus charcoal	~200	9020 $\pm$ 70	10250-10120
207168	IIIc	Pooled Pinus	251-254	9510 $\pm$ 80	11140-10560
2214115	IIf	Juniperus & Pinus charcoal	315	9990 $\pm$ 60	11200-11060
*PRI- 070-102- 3716		Charcaol	349	9990 $\pm$ 30	11420-11260

## CHAPTER 5

### RESEARCH DESIGN AND METHODS

#### Introduction

This thesis is conducted under the umbrella of a comprehensive field project conducted at North Creek Shelter. The larger project has its own design that in some aspects guides the body of this work. The unifying theoretical approach at North Creek Shelter is evolutionary ecology. Aspects of foraging theory are incorporated by all of the researchers –though perhaps not to the extent that this thesis addresses. Foraging theory will be used to make predictions and test hypotheses using data collected during excavation. Specifically, the dietary breadth model will be used by all of the investigators.<sup>1</sup>

This thesis research uses the dietary breadth model, thus making it compatible with other research and data collected at North Creek. However, I deviate from the overall research project by conducting a detailed critique of Optimal Foraging Theory. In contrast to Janetski (2007: 9) “The underlying premise and theoretical bases for optimal foraging models have been presented often and well, and repeat of those arguments in full seems unnecessary (Simms 1987; Broughton 1994, 1999 and the references therein),” I believe a careful evaluation of the applicability of Optimal Foraging Theory is warranted.



## Research Design

The main hypothesis is *Can the principles of Optimal Foraging Theory explain plant utilization in the early Archaic at North Creek Shelter?* Stated as a null hypothesis:

H<sub>0</sub>: The early Archaic occupants of North Creek Shelter were guided solely by optimal foraging principles in determining which plants to exploit.

H<sub>1</sub>: The early Archaic occupants of North Creek Shelter were not guided solely by optimal foraging principles in determining which plants to exploit.

In order to evaluate the thesis, two main objectives must be met. First, there must be an understanding of the paleoenvironment. Second, there must be an analysis of the early anthropogenic Archaic botanical materials from the North Creek Shelter site. The following questions and the methods used to address them are designed to meet these objectives and evaluate the hypothesis.

*What native plant resources were available to the early Archaic occupants at North Creek Shelter?* Understanding the prehistoric environment is the best way to determine the botanical resources available to the inhabitants at North Creek Shelter. Previously, no explicit anthropogenic research has been done to determine the available plant resources for the Escalante region during prehistory.

In order to understand the prehistoric environment, an environmental reconstruction is necessary. A reconstruction is an inductive process that takes into account the geology and geography of an area, and what is known about past weather systems. Finally, fossil evidence pointing to flora and fauna inhabitants of the area can be used. In ideal cases, pollen analyses are incorporated into these findings. This addition produces more fine-grained chronology and contributes substantial robustness to the environmental

reconstruction. Since no environmental reconstruction for the immediate project area has been conducted two reconstructions conducted in an area adjacent to the Escalante region are evaluated. Specifically, the reconstructions researched by Madsen (2005) and Thompson et al. (1993).

*What plant resources did the early Archaic occupants of North Creek Shelter utilize?*

The macrobotanicals recovered from early Archaic cultural contexts, such as storage pits and occupational use surfaces (e.g., strata F142, F58, F64, and F62) (Figure 4), were analyzed. This information provides a list of the botanicals present and the quantity recovered for each sample, and additionally the ethnographic implication of anthropogenic utilization.

In order to address the quantitative aspects of Optimal Foraging Theory, an understanding of resource ranking relative to caloric properties and cost/benefit in terms of acquisition and processing must be established. Ethnographic analogy from native groups, particularly the Southern Paiutes, gives insight to plant use at North Creek Shelter and information associated with acquisition and processing of plants. Literature review has been conducted on native groups and plant usage. Determining the resource or patch distribution is additionally very important in establishing acquisition costs that would be associated with biotic groups or individual resources. This literature review also considers relevant nutritional and topographic information to determine catchment and patch areas and cost/benefit analysis.

Cost/benefit analysis considers both the linear programming (Kelly 1985, after Reidheal 1979, 1980; Keen 1979, 1981) and the dietary breath model (Kelly 1985, after MaCarther and Pianka 1966; Emlen 1996). Both analyses have their strengths; however,

the dietary breadth model is more robust. Each analysis has its respective computation. Linear programming uses a linear algebraic equation to solve for multiple variables (calories, vitamins, etc.). The intersection of these variables gives a numeric value which can then be used to rank the resource relative to others. The formula follows:  $X_1, X_2, \geq 0$ . It was the first analysis of its kind to produce a solid mathematical model that could account for multiple variables other than caloric exchanges (Kelly 1995).

The diet-breadth computation takes into account caloric exchanges between the resource and the behaviors in acquiring a resource, again, allowing for the resource to be ranked, this time in terms of acquisition costs. The equation also allows for the addition of multiple resources to be factored for a holistic account of the diet. In this case:  $E$  = total kcal acquired while foraging,  $T$  = total foraging time (searching, gathering, and processing),  $E_i$  = kcal available in a unit of source  $i$ , and  $H_i$  = handling time per unit of resource  $i$ . The diet-breadth formula is:  $E/T = \frac{\sum \mu_i - E_i - T}{T_i + \sum \mu_i - H_i - T_i} = \frac{\sum \mu_i - E_i}{I + \sum -H_i}$  etc. etc. and so forth.

In evaluating resource rank, and thus Optimality of a resource, a resource is beneficial when the caloric acquisition exceed the calories expended to gather and process the resource. The cost/benefit for a singular resource (the dietary breadth is used for multiple resources) is illustrated by the following formula:

$$E/T = \frac{E_i}{T_i + H_i}$$

where  $Ei$  = resource's calories,  $Ti$  = acquisition calories, and  $Hi$  = processing calories. A higher result represents a correspondingly beneficial resource. Once these values are calculated multiple resources may be ranked relative to each other.

If the early Archaic occupants were behaving optimally at North Creek ( $H_0$ ), I would expect the recovery to reflect high-ranked plant resources defined by the cost/benefit principles of Optimal Foraging Theory. The recovery would thus yield the intensive use of one or two high-ranked resources, with very few low-rank resources in comparison.

If the occupants were not using optimality principles as the sole factor in their plant resource selection, ( $H_1$ ), I expect evidence of a low-rank, high-cost strategy whereby a high proportion of one or two low-ranking plants would be extensively exploited. It is also possible that the early Archaic occupants were using a broad-spectrum strategy, in which a relatively high proportion of multiple low-rank or various low-to-high-rank plants were being exploited.

## Methods

The primary data for this thesis is derived directly from the archaeological excavations at North Creek Shelter. Excavated soils were thoroughly screened through 1/8-inch wire mesh screens and recovered cultural materials, including botanical specimens, were sorted, bagged and recorded by respective unit levels. To collect the macrobotanicals associated with human activities, flotation samples were collected from cultural contexts such as hearths, storage pits, and habitation floors. Samples collected from early Archaic cultural contexts (e.g., strata F142, F58, F64, and F62) (Figure 4) are of specific interest to this thesis. Excavation of each unit was conducted to a depth such

that no cultural materials remained, bedrock was encountered, or the time allotment for the excavation prohibited further excavation.

The location where radiocarbon samples were taken and the associated cultural features were recorded. Upon completion of the excavation work, such information was recorded on fine-grained soil profiles and plan maps which were produced from all sidewalls and living surfaces.<sup>2</sup> This information was used to determine which of the collected botanical samples would best address the research questions.

After all the sediment and soil profiling work had been completed, the trench was backfilled. Archaeological materials, including botanical samples, recovered during excavation were brought back to Brigham Young University's Peoples and Cultures Museum for analysis and final curation.



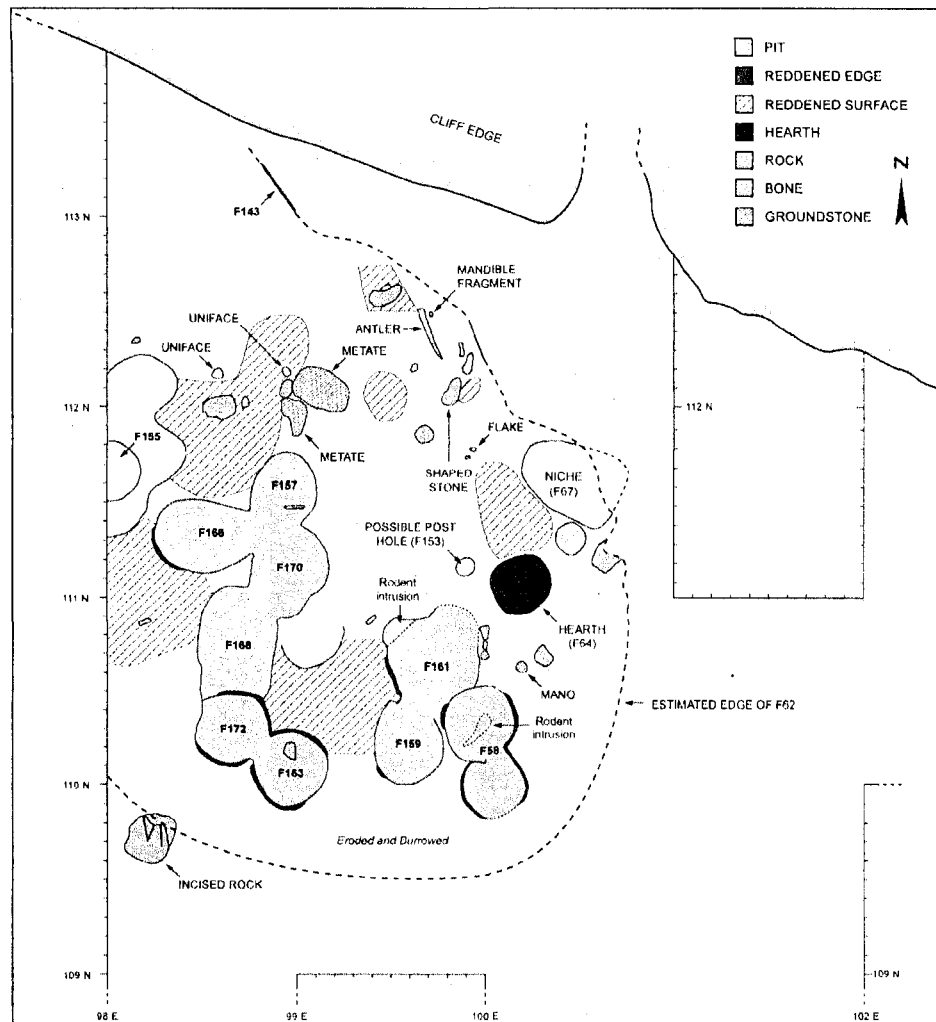


Figure 5: Plan view of early Archaic features (Janetski 2008).

### Flotation Methods for Recovery of Macrobotanical Remains

Most of the 2006 and 2007 flotation samples were processed in the field (Figure 6). The flotation technique can best be described as a combination of non-mechanical flotation and wet screening. This technique works well for detailed recovery of botanical remains from archaeological sediments. It is a preferred method when the soil samples

are small, or if recovery is expected be sparse, which is the case in this study (Scott-Cummings, personal communication 2006).

Samples were measured, with most containing approximately 1000 mL of sediment. The soil samples were floated in a 5 liter bucket to separate the light and heavy fractions. The light fraction was then decanted off and sieved through a 250  $\mu$ m US standard geological sieve. The heavy fraction was then water screened through a 500  $\mu$ m US standard geological sieve. The light and heavy fraction's recovery were laid out on newspaper to dry, and then bagged respectively.



Figure 6: S. Hill processing macro botanical samples.

#### Macrobotanical Sample Analysis

The light and heavy fractions of the flotation samples were sorted and identified using standard botanical comparative methods. This includes magnification and comparison



with standard physical collections and photographs in a laboratory setting. Sorting and analyzing flotation samples took place at the University of Nevada, Las Vegas archaeological laboratory facility.

A high quality Bausch and Lomb Microscope on a setting of 10x power was used to perform the macro analysis. Samples were laid on a glass surface and systematically drawn under the scope's line of vision. Botanicals (mostly seeds), lithics, and bone were removed when encountered. The latter two items were bagged and delivered to the respective analysts working on these materials for the site.

The recovered botanicals from screening and flotation were identified using comparative methods. Few macrobotanical remains other than seeds were recovered. Seeds were compared primarily with the standard Martin and Barkley's (1961, reprint 2000), *Seed Identification Manual*, the USDA online plants index, or a physical comparative collection. To a lesser degree, other smaller and less consequential references were sometimes used (Rhode 2002: Fagan 1998: Taylor 1992: Bowers and Wignall 1993: Elmore and Janish 1976).

## Notes

1. The Principal Investigator, Joel C. Janetski, has integrated all the major interests of the investigators working at North Creek so that each of our independent research needs are met. Congruently, we are incorporating universal themes into all of our work. The result will be that each of our autonomous projects will ultimately contribute to a monograph of the site.

I have conducted the botanical analysis for North Creek Shelter Excavations. Brad Newbold is analyzing the faunal remains. Mark Bodily is analyzing the lithic assemblage. All of us will be producing Masters Thesis work from elements of our respective analyses. Dr. Janetski and David Yoder have spent a great deal of research effort in on establishing subsistence and environmental change, particularly in the earliest leaves of the site. Additionally, a geologist and a graphics artist employed by Brigham Young University have been retained to provide services and input in our research.

2. An expert graphics artist, Scott Ure, who is familiar with archaeology and well informed about the project and the specific research questions has been employed to produce electronic maps and graphics.

The project has also benefited from consultation with Tom Morris of the Brigham Young University Geology department. Dr. Morris has been in consultation with the project and will visit the site during the 2008 field season in order to validate the nature of the primary sedimentary depositions and associated environmental indications. Additionally, indicators of post-deposition deformation have been identified. These analyses are available for the benefit of this thesis.

## CHAPTER 6

### RESULTS

#### Early Archaic Environmental Reconstruction

Due to its immediate location and topographical inclusiveness, The Grand Staircase National Monument is the most applicable environmental analog for North Creek Shelter. Unfortunately, no long-term environmental data has been collected on weather patterns in the monument. However, the BLM has been monitoring several long-term weather stations around central Utah. The weather histories of these surrounding areas along with other lines of evidence were used to make inferences concerning the early Archaic environment at North Creek Shelter.

Currently, environmental reconstructions from areas surrounding the Escalante region represent two different scenarios for the Archaic climate. These environmental reconstructions were conducted in order to understand the epic Terminal Pleistocene/Early Holocene (TP/EH) transition ( $\approx 9000$  BP); the Archaic falls within the early Holocene. The differing views of the climate during this time are that the environment of the Great Basin during the early Holocene was cooler and wetter than today Madsen (2002), or the early Holocene was significantly warmer than today (Thompson et al. 1993).

Currently the northern Colorado Plateau experiences 100-120 frost-free days a year. The inclusive Kanab Plateau has highly variable precipitation. For example, the Kanab

received 15.7 cm of precipitation in 1989 and 22.8 cm in 1995 (Geib 2001). If the modern dynamics in precipitation have any resemblance to the past, then Madsen's (2002, 2007) environmental reconstruction describing variable precipitation and temperatures ranging 3-6 C° cooler during the Archaic is most plausible.

Additionally, research covering a broader time frame suggests that Madsen's interpretation is more likely. Prior to the TP/E transition (12,000 to 9,000 BP) we know the paleoenvironment was also highly variable in temperature and precipitation (Madsen 2007). Evidence from packrat midden analyses suggests that this trend was both cooler and wetter then after the TP/EH transition (Betancourt 1984, Betancourt and Davis 1984). This suggests a trend of variable precipitation with temperatures slightly rising overtime starting from the mid-Pleistocene forward.

This trend has been confirmed by other researchers who have evaluated differing lines of evidence and have developed conclusions similar to Madsen's (Grayson 1993; Wigand and Rhode 2002). The resulting environment based on Madsen's, Grayson's, and Wigand and Rhode's conclusions has been discussed in Chapter 3. In essence, the biota environment would have been very similar to today. The exception would have been the lowering of some alpine biomes and reduced occurrence of pinyon, agave and mesquite complexes.

Thus, the present day biota is a reasonable analog for what resources and their distribution would have been available to early Archaic inhabitation of North Creek Shelter. Resources would be distributed in inconsistent patches. However these patches would be within reasonable travel distance from the shelter.

## Ethnographic Botanical Review

Because the archaeological assemblages of the Escalante region during the late Pleistocene (about 8,000 BP) represent similarities with the material culture of the Utah Southern Paiutes and Pleistocene groups are believed to have practiced a hunter-gatherer lifeway in the same region, they have been used for inference and analogy on plant use. However, when appropriate other ethnographic groups that used the same plant complexes have been referenced. Unless otherwise stated, the ethnobotanical accounts given are for the Utah Southern Paiutes. The following accounts follow Table 1, introduced in Chapter 3.

In conjunction with the ethnographic data, nutritional data allows for ranking of individual resources and qualifying motivations for their exploitation. Most of the cost/benefit analyses for these resources have been previously inferred or calculated by other researchers (e.g., Hawkes and O'Connell 1982; Simms 1987). Additional nutritional information was accessed from the United States Department of Agriculture's online data bases (USDA ARS).

Amaranth Family (*Amaranthaceae*). To avoid confusion, Amaranth *A. albus*, shares the same common name "pigweed" with the *Chenopodium* genus of the goosefoot family (Ebling 1986). Pigweed *Amaranthus graecizans* is a widely distributed plant throughout North America. It is reasonable to assume that it would have been available in the Escalante region during the late Pleistocene, as it is today. The plant grows in disturbed areas and has small but prolific seeds.

Many Native American groups eat pigweed shoots as fresh greens (Ebling 1986). Seeds were harvested by gathering mature plants and drying them. The seeds were then

beat-out and parched. Seed were eaten whole or ground into flour meal for bread, cakes, and mush. Often, it was added to cornmeal by pueblo groups (Ebling 1985).

Sumac Family (*Anacardiaceae*). Smooth Sumac (*Rhus gabra*) a small bush, is currently common in the southwest. However, it can be found as high north as British Columbia (Ebling 1986). Ebling (1986, 504) generically refers to “Indians” eating the berries fresh, drying them for the winter, or crushing them into a drink.

Skunkbush Sumac (*Rhus trilobata*) prefers dry rocky slopes and cliffs between 4800 and 6600 feet (463-2011 meters). The fruits were eaten fresh, dried for storage, or crushed and seeped to make drinks. Skunkbush was considered superior by the Southern Paiute for basket making material. Paiutes were observed tending (transplanting, pruning and burning old growth) skunkbush groves to assure there success (Rhode 2002, after Zigmond 1981).

Parsley Family (*Apiaceae*). Arrow balsamroot (*Balsamorhiza sagittata*), a perennial herb, was utilized in its entirety—the whole plant was eaten. The greens and roots were eaten raw. Leaves were preferably boiled. The seeds could be gathered in the early summer, and winnowed and parched for winter storage (Ebling 1986). Sometimes the parched seeds were ground into meal. When cooked, it would produce an oily mush (Strong 1969).

Common Sunflower (*Helianthus annuus*) was an important resource. Sunflowers grow prolifically in disturbed areas, both natural and man-made, making it an ideal horticulture plant. However, *H. annuus* was likely introduced to the Great Basin from the East after the terminal Pleistocene (Ebling 1986).

Big Sagebrush (*Agoseris tridentate*) was a very important plant, used as a food resource and for utilitarian purposes. Seeds were ground and eaten as meal. Because of their strong bitter flavor, sage seeds were added to other meals such as Rice Grass (Rhode 2002; Ebling 1986; Kelly 1938). Incidentally, Big Sage was never used for agave roasting because it tainted the normally sweet agave with a bitter flavor (Rhode 2002).

Infusions of Big Sage were used to treat many topical ailments, including scars. Tea infusions were also drunk to help with stomach ailments and headaches. Women drank the infused sage tea during menstruation, and Big Sage was the only thing that menstruating women would use to scratch themselves. Mothers bathed new infants with such infusions, and after an ill person recovered their habitation site and any personal items were wiped with sage leaves or infusions (Rhode 2002).

Barberry Family (*Barberidaceae*). Fremont barberry *Barberis fremontii* is an evergreen shrub that is distributed and used much like elderberry (see below).

Mustard Family (*Brassicaceae*). Tansy mustard or Pepper Grass *Descurainia* spp. is an annual plant that grows predominately in high desert or foothills. In the spring the leaves were gathered for greens, which were boiled for eating. The seeds were parched with basket parching trays, after which they were ground into flour. The flour was used to make mush, and often it was mixed with other seeds to make them more palatable (Ebling 1986).

Desert Prince's Plume *Stanleya pinnata* provided early spring greens. The plants were often maintained to promote their success (Rhode 2002, Fowler 1996). Greens are similar in nutrition to spinach. The Greens are boiled and pressed in cold water to

remove selenium, which otherwise may be present in toxic levels. This processing also removes some of the bitter flavor making Prince's Plum more palatable (Rhode 2002).

Yellow Crest *Rorippa curvisiliqua* is a perennial which grows at high elevations (Ebling 1986). It produces a tiny brown seed that would likely have been processed by indigenous groups. The only reference has been for the Owens Valley Paiutes in which Steward (1933) reported the seeds being processed—this is likely in error because Yellow crest would not grow at this elevation (Ebling 1986).

Cacti Family (*Cactaceae*). Prickly Pear (*Opuntia* sp.) was likely as common in the Escalante area as they are today. The Utah Southern Paiute would knock the fruits off with a stick, collect, flash-burn to remove the quills, and eat the fruit. This process produces a sweet tasting fruit with a texture like a very ripe mango. The pads were sometimes treated the same way; however, more often, the pads would be dried for storage. The dried pads could be boiled, preferably with salt, and then eaten (Rhode 2002). The Timbisha and Kawaiisu were observed harvesting and eating the flowers. Prickly Pear was also ideal for making wine (Ebling 1986).

Mammillaria (*Mammillaria tetrancistra* & *Neolloydia johnsoni*) are used much in the same way as Prickly Pear with the addition that seeds were also eaten. The dried cactus was roasted to remove the spines and the pads were eaten fresh or dried and stored for latter consumption (Ebling 1986).

Cottontop cactus (*Echinocereus engelmanni* & *polycephalus*) was used primarily for its seeds, however its flesh was ground into flour and used for medicinal purposes, such as a topical for burns (Rhode 2002). I would suspect that the plant's cotton would have also been used; however, there is no ethnographic account available.



Honeysuckle Family (*Caprifoliaceae*). All Elderberries *Sambucus* spp. are edible except *S. microbotrys*, which is poisonous to humans (Kearny and Peebles 1960). The shrubs grow from 5600 to 9100 feet (1707-2774 meters) of elevation. The berries could have been harvested in mid-summer and were eaten fresh, boiled to make jelly, or dried for winter food stuffs (Rhode 2002).

The Elderberry plant was used medicinally. Leaves and flowers were boiled and the steams were used to relieve headaches and cold symptoms (Rhode 2002; Zigmond 1981). Blue Elderberry *S. ceruea* branches were hollowed-out and used by Southern Paiutes to make ceremonial flutes. Additionally, these hollowed branches were used for smoking tobacco (Rhode 2002). In the proto historic period, and likely before, elderberries were an important trade item for the Utah Southern Paiutes (Ebling 1986).

Chenopod Family (*Chenopodiaceae*). Fourwing Saltbush (*Allenrolfea canesceus*), Big Saltbush (*Allenrolfea lentiforrnis & powelli*), and Shadescale (*Allenrolfea confertiolia*), were all utilized for seeds (Fowler 1986). These woody bushes grow commonly below 7500 feet (2286 meters) elevation in the Great Basin (Rhode 2002), preferring saline or alkaline soils (Ebling 1986).

The fresh roots of Fourwinged Saltbush were boiled. The hardwood of the plant was used to make arrow shafts and arrowheads (introduced later than the terminal Pleistocene) (Rhode 2002). Big Saltbush was generally reported to be exploited the same way the smaller fourwinged variety was.

Shadescale, besides being used for seeds, was also used medicinally; the plant was ground into a fine powder to be used as an antiseptic. David Rhode (2002) explains that people still use it often today to heal cuts. The seed of Iodine bush (*Allenrolfea*

*occidentalis*), which has been found in numerous Great Basin archaeological sites, was likely harvested, winnowed, and ground into flour.

Goosefoot Sub-Family *Chenopodium* (*Chenopodiaceae*). Goosefoot (*Chenopodium fremontii* & *incanum*) was primarily eaten as greens. They were usually boiled alone or with fatty meat (Rhode 2002; Ebling 1986; Fowler 1986). The seeds of these varieties and Slimleaf Goosefoot (*Chenopodium leptophyllum*) were harvested in late summer (Fowler 1986). Seeds were collected with a seed-better and basket, parched, and ground into meal (Rhode 2002).

Other chenopods, such as Russian thistle (*Salsola kali tenuifolia*) and Winterfat (*Eurotia lanata*), which are not so succulent, could be collected after a rain at which point they were softened making them palatable (Ebling 1986). Winter fat was also used by the Timbisha as a tea for respiratory ailments (Rhode 2002). Various scalp conditions, such as lice and balding, were treated with winter fat that was made into shampoo (Rhode 2002, after Murphy 1959).

Black greasewood (*Sarcobatus vermiculatus*), was used for its seeds, however, they were more frequently used for their hardwood. Greasewood was preferred for digging sticks, cradle boards, and basket edges (Rhode 2002).

Seablite and Seepweed (*Suaeda* spp.) were utilized for their seeds (Fowler 1986) and the greens were eaten (Rhode 2002). Additionally, the leaves and stems were mashed into a topical poultice (warm moist topical to extract infection) that was applied to open cuts and sores. It could also be made into tea used to treat bladder and kidney ailments (Rhode 2002).

Gourd Family (*Cucurbitaceae*). Calabazilla or Buffalo Gourd (*Cucurbita foetidissima*) grows in low desert locations. The fruits are attractively striped and approximately 10 cm in diameter (Ebling 1986). Among the Cahuilla, seeds were collected and dried. The dried seeds were ground into flour and used to make mush. Containing 33 percent protein and 33 percent oil they were a valuable food-stuff (Ebling 1986).

The Cahuilla also cut the root and gourd into small pieces, stored them, and used them for soap (Ebling 1986). The soap pieces could be ground to make shampoo (Ebling 1986, following Curtin 1947). Calabazilla's yellow flowers were used for dye (Ebling 1986). The gourd can be hollowed out and dried and may have been used in prehistoric times as a functional storage container.

Sedge Family (*Cyperaceae*). Tule Bulrush (*Scirpus acutus*) is a perennial that grows in fresh and brackish marshes up to 5000 feet (1524 meters) in elevation (Ebling 1986). Tule was highly utilized for both food and utilitarian items. Tule was generally used the same as Cattail (discussed below), the notable difference being that the *S. acutus* has a much sweeter flavor (Ebling 1986).

Oleaster Family (*Eleaginaceae*). Silver Buffaloberry (*Shepherdia argentea*) grows along rivers up to an elevation of 6500 feet (1981 meters). The 4-6 mm fruits were harvested by hand or by beating the bush with a stick and collecting the fallen fruits. The fruits were eaten fresh or boiled. Sometimes northern Great Basin groups would add buffalo meat (Ebling 1986).

Health Family (*Ericaceae*). Greenleaf and Pointleaf Manzanita (*Arcrostaphylos* spp.) are woody evergreen shrubs utilized for their fruits (Fouler 1986; Ebling 1986). The

shrub grows in abundance on the foothills around 4000 feet (1219 meters) (Fowler 1986; Ebling 1986).

Ethnographic accounts are available from native central California groups and the Owens Valley Paiutes. These groups mashed the berries and soaked them in water to make a drink. The Wintuns and Yokutes made coarse flour which they would reconstitute as a cider (Ebling 1986, after Powers 1877).

Pea Family (*Fabaceae*). Skunktop and Beaverhead Scuirpea (*Psoralea castoreathe* & *mephitica*), often called Indian or Wild turnip, roots were eaten (Fowler 1986). The bulbous roots were dug for with fire tempered digging sticks. According to the ethnographic accounts, the food was not highly regarded and was considered a “starvation food.” Once the hard skin is removed the tubers can be eaten raw or boiled (Ebling 1986).

New Mexico Locust (*Robinia neomexicana*), a large bush/small tree, grows in a wide variety of elevations. They commonly grow alongside mesquite. However, unlike mesquite that need a ground water source, locusts can grow in very dry areas. Fowler (1986) reports that the Paiutes eat the locust flowers.

Beech Family (*Fagaceae*). Gambel’s and Scrub Oak (*Quercus gambelii* and *turbinella*) are deciduous and evergreen trees, respectively (Ebling 1986). Both prefer rocky slopes near washes and springs between 5400 and 7500 feet (1646-2286 meters) of elevation. The trees produce small acorns in summer (Rhode 1986).

Unlike other varieties of acorns (e.g. Black Oak *Q. kelloggii*), Gambel’s Oak acorns were not leached to remove toxins. Rather, they were pit roasted or boiled, then ground into meal (Rhode 2002; Steward 1941; Soffle et al. 1989).

Acorns are an important food stuff in the Great Basin. Acorns are nutritionally similar to pinyon nuts, except with less fat and protein, yielding approximately 2120 calories per pound (Rhode 2002).

Iris Family (*Iridaceae*). Wild Iris or Rocky Mountain Iris (*Iris* spp.) are perennial herbs with a rhizome root. Though little ethnographic information is available, we do know that the Wappo and Miwok used the Iris fibers for cordage and in the foundation of baskets (Merrill 1923; Heizer and Elsasser 1980). The seeds could also be made into flour (Ebling 1986, after Beals and Hester 1974) and theoretically the roots could have been dried and ground into flour.

Lily Family (*Liliaceae*). Mariposa Lilly (*Calochortus* spp.) and Wild Onions (*Alliums* pp.) are bulb plants that generally occur from 4000 to 7000 feet (1219-2134 meters) in elevation (Rhode 2002). The plants usually have one bulb, but may have as many as four. The bulbs generally do not store well so they were usually roasted within a few days of harvesting (Ebling 1986). Harvesting occurred in spring with use of digging sticks (Rhode 2002). Among the Owens Valley Paiutes the greens were also harvested (Rhode 2002; Kelly 1964).

Nutritionists note that the bulbs are a good source of starch; additionally many believe that Wild Onions increase the intake of thiamine (vitamin B1) from food ingested concurrently (Ebling 1986, after Mead 1972).

Blazing Star Family (*Loasaceae*). Desert and White Stemmed Blazing star (*Mentzelia* spp.) are a perennial and annual herb, respectively, that grow in dry gravelly disturbed soils (Ebling 1986). The seeds from Blazing Star were harvested in late summer. The seeds were gathered by pouring them out of their long pods. Seeds were

parched in parching baskets or put in hot water where they dissolved to form a gravy (Ebling 1986). Sometimes the seeds were ground into pinole (fine uncooked meal), which was considered a delicacy (Strong 1969). Likewise, White Stemmed Blazing star seeds were ground and served as a special treat, but only after parching (Ebling 1986, after Hough 1898).

Loosestrife Family (*Lythraceae*). Purple Ammania (*Ammannia coccinea*), is an annual plant that occupied lower elevations. Ethnobotanical data is scarce. Ebling (1986, 432) gives this account; "Seeds of *A. coccinea* were gathered, prepared, and eaten by the Mojave and Yuma Indians."

Mallow Family (*Malvaceae*). Mallow (*Sphaeralceae* spp.), is a perennial desert shrub that primarily grows below an elevation 7000 feet (Rhode 2002). The fruits were eaten fresh, and the seeds were roasted and ground into meal (Rhode 2002). The leaves could also be eaten fresh or cooked. The Hopi were observed chewing the "mucilaginous stems" (Ebling 1986, 505). A general medicinal drink was made by boiling the roots (Rhode 2002).

Broomrape Family (*Orobanchaceae*). Broomrape *Orobanche* spp. is a parasitic succulent herb plant that grows off the roots of other shrubs. Broomrape prefers sandy soil and grows in clusters (Rhode 2002; Ebling 1986). The entire plant was eaten raw or roasted. The Cahuilla harvested the root in the spring before the plant bloomed, and preferred it roasted (Ebling 1986). Broomrapes fleshy constitution made it good food stuff for travel because it could be used for both food and water (Rhode 2002).

Grass Family (*Poaceae*). Indian Rice Grass (*Oryzopsis hymenoides*) was harvested in early summer. Bunches were gathered just as the seeds were ripe, preferably on the

green side. Bunches were piled and threshed by beating with a stick then winnowed in basket trays to remove the seed. Unripe seeds could be gathered by harvesting bunches of stalk. The stalks and shafts were flash-burned to release the seeds. The seeds were ground into flour which has a mild taste; thus, sage and other grass seeds were often added to the meal to give a more robust flavor (Rhode 2002).

Wild Rye grows in bunches up to six feet tall. The seeds were a valued food resource but the stalks were also used to form mats and cradle boards. From ethnographic accounts, it appears that Wild Rye was valued more for its fibers than as a food resource.

Likewise Scratch Grass and Dropseed appear to be most sought for their utilitarian products. Scratchgrass seeds were important to the Southern Paiute economy; however, the plant was most utilized for basket making, as it makes a good coil foundation.

(Ebling 1986) Dropseed, like rice grass, has a very mild flavored flour and was used much the same way. In the southwest the Hopi liked the flavor of dropseed mixed with corn meal (Ebling 1986).

Common reed *Phragmites australis* grows in fresh water marshes and springs. Reed seed were collected and either dried winnowed and ground into flour or the whole seed was boiled and eaten (Kirk 1970). The roots were eaten raw, roasted, or boiled and leaves were boiled. Reed canes were used for atlatl dart shafts. Reed leaves were ideal for making baskets, mats, screens, and cordages for nest and snares (Ebling 1986). Often mistaken for cattails by laypersons, in many regards, they were used similarly by indigenous peoples.

Purslane Family (*Portulacaceae*). Bitterroot lewisia (*Lewisia rediviva*), is a perennial herb that grows between 2500 and 5500 feet (762-1676 meters) of elevation. The starchy

roots were boiled to remove the hard outer coating which can be very bitter. Boiled roots were dried and stored for winter use, when they would be reconstituted in boiling water and added with other foods to form a soup (Ebling 1986, after Sweet 1962).

Rose Family (*Rosaceae*). Saskatoon, and Utah and Serviceberry (*Amelanchier* sp.) produce fruits similar to Currents. These bushes grow between 5000 and 8000 feet (1524-2438 meters) of elevation (Ebling 1986). The fruits ripen and dry on the vine, remaining on the branches until late fall. Southern Paiutes would gather the fruits in fall for winter food stuffs (Rhode 2002). Additionally, the fruits were a preferred ingredient in pemmican (Rhode 2002). The wood from Service Berry was appropriate for cradleboards, basket rims, digging sticks (Rhode 2002, after Kelly 1964; Steward 1938; Zigmond 1981).

Sandalwood Family (*Santalaceae*). Bastard toadflax (*Comandra Pallid*), is a small, widely distributed fruiting bush. Great Basin Paiute groups used the seeds for food (Fowler 1986; Mahar 1953). The small nut-like seeds were a favorite of Shoshone children (Mahar 1953). In addition to food, the Navajo used the plant to make an infusion for eyes, sore feet, canker sores, and if drunk, as a narcotic (Wyman and Harris 1951).

Saxifrage Family (*Saxifragaceae*). Golden Currant (*Ribes aureum*) is a shrub that grows on moist river banks (Ebling 1986). Ethnographic information is scant. The shrub produces a berry that the Paiute preferred to eat cooked (Ebling 1986).

Night Shade Family (*Solanaceae*). Anderson Wolfberry or Desert tomato (*Lycium* spp.), is a small shrub with 4-8 mm long fruits. It is common on alluvial fans and desert mount slopes. Picking the fruits is difficult due to the plant's thorns. Harvesting occurred



in the early spring. Fruits were beaten off the plant into baskets. Fresh berries were eaten raw or juiced, otherwise they were dried whole or mashed (Rhode 2002; Zigmond 1981). Desert tomatoes were a staple for Owens Valley Paiutes. They would dry and grind the fruits, reconstituting them with water for eating (Ebling 1986).

Rhode (2002) explains that tobacco (*Nicotiana* spp.) was a very important southern Great Basin Plant. It is a about 1-2 feet tall biennial/perennial that prefers to grow around limestone between 2600 and 4800 feet (792-1463 meter) of elevation. "The leaves were smoked for medicine, ceremony, and pleasure" (Rhode 2002, 124-126). Southern Paiute women would harvest, dry, and grind the leaves. The grounds were mixed with water. The resulting paste was rolled into large balls which plugs were removed as needed. These women would chew the plugs, "*so-go*", while gambling and socializing. Men were observed smoking *so-go* (Rhode 2002, Steward 1933).

Cattail Family (*Tryphaceae*). Cattails (*Typha* spp.) are perennial. Typically the plants form dense stands of long grass-like leaves averaging about 1 inch in diameter. They are found on the shores of marshes, ponds, and lakes, but also in slow rivers, ditches, seeps, and springs.

Cattail comes in two varieties: Southern, (*Typha domingensis*), and Broadleaf, (*Typha latifolia*). Southern Cattail grows in saturated alkaline environments below 3900 feet, while Broadleaf grows in seeps and shallow water from 3900 and 5000 feet (1189-1524 meter) (Rhode 2002).

All parts of the plant are edible and highly nutritious. Both ethnographic and modern accounts describe cattail as palatable if not delicious. Pollen was collected in the summer

and could be stored. Pollen was used alone like flour or mixed with other flours to make cakes (which resemble yellow pancakes.)

Seeds were processed and eaten. Ethnographically the Kawaiisu would flash burn-off the cottony fluff. This cleaned the seeds and toasted them at the same time (Rhode 2002 after: Zigmond 1981).

The flowers and stocks were eaten raw, as was noted among the Kawiisu and the Southern Paiute (Rhode 2002 after: Zigmond 1981). The Southern Paiute often made soup out of the flowers, stocks, and greens (Rhode 2002 after: Bye 1972).

The rhizomes roots are sweet in flavor and can be processed in a variety of ways (USDA). They were eaten year round, however predominately in the winter and spring (Rhode 2002 after: Kerr 1936, Steward 1933, Stoffle et al. 1989, Zigmond 1981).

In addition to edible uses, the cattail provides important non-edible resource. Leaves were used to weave baskets and mats. Stems were used to make baskets, decoys, shelters, and boats (Rhode 2002 after Millers, pers. communication, Stoffle et al. 1989). Dried plant parts, specifically stems and fluff, were used as tinder to start fires. As a testament to the plants significance, all parts of the plant were dried and stored for year round use (Rhode 2002).

Valerian Family (*Valerianaceae*). Edible Valerian (*Valeriana edulis*), a perennial that grows in rich, moist soil, is most often found in coniferous woodlands around 7000 feet (2134 meters) (Ebling 1986). Though little ethnographic information is available, the tubers were likely boiled and eaten by indigenous groups (Ebling 1986, after Bartlett 1943).

Tobacco Root (*Valeriana edulis*). is a herbaceous plant that grows throughout the Great Basin. It has a root that is poisonous raw, but palatable when cooked. Groups who did eat the root used roasting as a preferred cooking method (Moemen 1998). In addition to food, the root was often pounded into a pulp and applied to bruise and body aches (Moemen 1998, after Blankinship 1905).

Grape Family (*Vitaceae*). Canyon grape (*Vitris arizonica*), is a large woody vine that grows in wet moist soil between the elevations of 2200 and 5000 feet (671-1524 meters). The fruits were eaten raw or cooked and could be dried and stored for year round consumption (Rhode 2002). Ebling (1986) notes the fruits are not very palatable. Soffle et al. (1998) and Bartlett (1943) suggest that grapes were also made into jam and wine.

Mesquite and Agave complexes. It is worth mentioning the Mesquite (*Prosopis* spp.) and Agave complexes (*Agavaceae* & *Yucca* spp.), although, it is unlikely that they were significantly available in the region. Data from the site support the interpretation that Mesquite and Agave were rare in the site area. However, data is still scant and the environmental data for the Escalante Basin during the terminal Pleistocene is not refined enough to make a positive assumption in this regard. For example, Madsens's (2005) interpretation, based on pack rat middens and geological information would suggest the availability of these resources, while Thompson's (1993) data is based on packrat middens and pollen analysis suggest that it would have been too wet and cool to support these flora. Note that the dispute is over 3 degrees centigrade and 1-2 inches of annual rainfall, so the dispute itself is on the extreme marginal end of the plants' ability to inhabit the area. With this said, I will discuss the two complexes.

Mesquite is an important Mojave and Sonoran resource. Incidentally, mesquite is has approximately 1540 calories per pound (Rhode 2002). Ethnographically groups would camp for extended periods of time at mesquite groves. This is not surprising, considering mesquite provides shade, food and attracted game animals interested in the same (Rhode 2002). Mojave and Ash Meadows natives were known to prune and clean out the undergrowth to make living and gathering around the thorny trees easier (Rhode 2002; Steward 1939).

Mesquite pods can be gathered and eaten both green and ripe, allowing for the beans to be harvested from spring to late summer (Fowler 1986). Besides the usual ground into flour meal and roasting processing, the green beans were often smashed to make a juice drink that was rather sweet (Rhode 2002). Meal was used to wean children and leaves were once used medicinally; water infused with the leaves can be used as eye drops. Additionally, the ripe pods were prized by groups outside the ecozone and were a highly priced trade item (Ebling 1986).

Utah agave was utilized most often by roasting the inner stalk in pits to make it more palatable (Rhode 2002). The leaves were sometimes roasted. Early ethnographers noted that the roasted leaves tasted like burnt sugar (Kelly 1964). The stalks and leaves were cut into what the Paiute called *yont*, or as we call them quid's, which after chewing produces a mass of fibers that were discarded (Rhode 2002). The stalk could be scored and the sap collected, and once fermented it produced an intoxicating drink (Ebling 1986).

Diel Yucca, sometimes called banana yucca, was primarily harvested for its fruits (Fouler 1986). However the seeds, bulbs, and buds were used as well (Rhode 2002). All

ethnographic groups accounted noted the superiority of the Dieh yucca fruits to other yucca varieties. Most Native's preferred to collect the unripe fruits before birds and insects would eat them and then let them ripen inside their home. San Felipe Indians cooked immature fruits to form a thick liquid which they reduced to store for winter use (Ebling 1986). The Zunis and Cochitis considered the fruits a luxury item, preferring to eat the fruits raw or slightly blanched. However they would also preserve the fruits by sun drying. The Navajo would spend 10-14 days gathering and drying the fruits (Ebling 1986). The heart of the banana yucca was traditionally used for soap and shampoo, and Southern Paiutes still use it ceremonially (Rhode 2002). All the agave complexes were highly utilized for their fibers. Everything from sandals to slow burning matches were made from agave fibers (for an in-depth account see Kelly 1964).

#### Botanical Cost/Benefit Ranking from Ethnographic Review

There are several methods for evaluating cost/benefit resource ranking. These may have minor variations but fall into one of two overarching approaches introduced and discussed in Chapter 2, Dietary Breadth and Linear Programming.

##### Dietary Breadth Evaluation

The Dietary Breadth model accounts for the total caloric return from both individual and multiple resources. Its strength is that it provides a predictive behavioral model that accounts for human choice and cultural differences in acquisition pertaining to processing costs.

Following Hawkes, Hill and O'Connell (1982), high-ranking plants from the accounts above, would include Tansy Mustard (*Descurainia* spp), at a 1307 kcal/hr and Bitter Root

(*Lewisia* spp), which is comparable to Agave (*Agavaceae*) at a 1237 kcal/hr return rate. The seeds from Chenopods border the high and middle categories of cost/benefit ranking. Chenopods include Fourwing Saltbush (*Allenrolfea canesceus*), Big Sedge (*Agroseris tridentata*), Saltbush and Shadscale (*Allenrolfea* spp.). Additionally, chenopods include the sub family Chenopodium. The highest ranked of these is Shadscale seeds with a return rate of  $\approx$  1200 kcal/hr.

Mid-ranked items include sunflower (*helianthus* sp.), with a 467-504 kcal/hr return rate, Rice Grass (*Poa* sp.) at a 301-392 kcal/hr return rate, and Wild Rye, with a 266-473 kcal/hr return. Other grasses, cattail (*Typha* spp) and Bullrush have a 128-273 kcal/hr and a 160-257 kcal/hr return rate, respectively.

Grasses (*Poaceae*), including cattail (*Tryphaceae*), need explanation. Seed grasses vary greatly in their ranking. Since grass seeds are generally high calories, the low ranking is a result of varying acquisition and handling costs. Thus, under the principles of Optimal Foraging, members of the high calorie grass family are often low-ranked resources.

Other low-ranked resources include Cacti (*Cactaceae*), at 84 kcalories per pound, other succulents such as Broomrape also have a very low kcal/hr return. Berries such as Fremontberry and Elderberry, Andersonberry, Wolfberry, Golden Current (*Saxifragaceae*), and Serviceberry (*Rosaceae*), though high in calories, are generally considered low ranked due to the acquisition costs. Wild Grapes (*Vitis arizonica*) are even lower in calories and have similar acquisition costs as berries.

Most plant greens, which are commonly gathered and treated as pot herbs, are low-rank due to low caloric content. Under the dietary breadth cost/benefit model, the greens

from Blazing Star (*Loasaceae*), Goosefoot (*Chenopodium*), Sunflower family (*helianthus* *sp*), and tobacco fall into a low- rank. Table 4 summarizes the previously discussed rankings.

TABLE 4 SUMMARY OF RANKING
<u>High Rank</u> Mostly Chenopods
Chenopods including: Fourwing Saltbush ( <i>Allenrolfea canesceus</i> ), Big sedge ( <i>Agroseris tridentata</i> ), Saltbush and Shadecale ( <i>Allenrolfea</i> spp.). Tansy Mustard ( <i>Descurainia</i> spp), Bitter Root ( <i>Lewisia</i> spp), Agave
<u>Mid-Rank</u> Mostly Grasses and Roots
Sunflower ( <i>helianthus</i> sp.), Grasses (Poesia sp.) such as Rice grass and Wild rye, Cattail ( <i>Typha</i> spp), Bullrush ( <i>Scirpus</i> sp.)
<u>Low-Rank</u> Cacti and Berries Greens and some Grasses
Cacti ( <i>Cactaceae</i> ), and other succulents Berries: Fremontberry and Elderberry, Andersonberry, Wolfberry, Golden Current ( <i>Saxifragaceae</i> ), and Serviceberry ( <i>Rosaceae</i> ), Wild Grapes ( <i>Vitris arizonica</i> ), Grasses ( <i>Poaceae</i> ), Greens

### Linear Programming

The linear programming model has advantages because it accounts for dietary variables other than calories (i.e., fat, carbohydrates, and vitamin and mineral nutrients). It should be noted these are nutritional properties, linear programming does not account for other desirable traits such as storage potential.

Dietary constraints are important in linear programming and its interpretation. In essence, linear programming works well in rationalizing why a resource may more desirable than its rank solely upon caloric exchange. For example, Cacti, though mostly

water and thus low in calories, may be desirable since it contains 21.8g of carbohydrates, and 331mg potassium per pound (Watt and Merrill 1974, USDA ARS).

The ethnographic record of the Utah Southern Paiutes suggests that that they ate a wide variety of resources and likely did not suffer from endemic nutritional deficiencies that would significantly sway resource desirability. However, caution should be used when using the ethnographic record in this regard. The Southern Paiutes were exploiting the highly nutritious Pinyon nuts at contact. It is widely believed that Pinyon was not available during the early Archaic prior to ~7500 BP., suggesting that we do not have an appropriate ethnographic analog for evaluating the early Archaic diet with the linear programming model (Mehring 1986: 44-47).

Pinyon has a high cost/benefit return rate of  $\approx 1,408$  kcal/hr (Kelly 1964). Under linear programming principles, Pinyon's high protein and fat content make it even more desirable. Pinyon is highly nutritious, in addition to having 629 kcal per 100 grams it contains 19.30g carbohydrate, 13.69g of protein, and 68.37g of lipids (fat). Furthermore, Pinyon is high in Magnesium, Potassium, Vitamin C and Niacin. Under principles of Optimal Foraging, the addition of this resource to the botanical assemblage may alter the overall plant resource exploitation strategy.

Furthermore, if Mesquite and agave complexes were exploited it would be an optimal choice. Both Mesquite and agave have high caloric content that gives them a high resource rank on the dietary breadth cost/benefit continuum. Furthermore, both resources are storable and would have the significant value under linear programming.



## Macrobotanical Recovery Results

Macrobotanical analysis of 6 specimens and 19 flotation samples from early Archaic levels and features from North Creek Shelter yielded the results listed in Table 6 and Table 7. Due to preservation, the recovery contained few botanicals other than charred seeds and charcoal. A total of 412 whole or mostly intact seeds were recovered. Macro recovery yielded 6, and the flotation yielded 406 seeds from approximately 14 liters of soil. The 6 macro specimens were uncharred, and the flotation yielded two uncharred seeds, one Tansy Mustard the other Cacti.

In short, the seed recovery was classified as Large *Amaranthus* and *Atriplex* (288 ct), small *Amaranthus* or *Chenopodium* (62 ct), *Poacease* (42 ct), *Celtis* sp. (3 ct) and several unknowns. Respectively, these most likely represent: high and mid ranked Sage and SaltBrush (large *Amaranthus* and *Atriplex*), Amaranth and/or Goosefoot (Small *Amaranthus* or *Chenopodium*), and mid-low ranked Wild Rye and Rice Grass (*Poacease*), and Hackberry (*Celtis* sp.).

Macro botanical remains recovered from flotation samples taken from early Archaic cultural contexts, such as storage pits and occupational use surfaces (e.g. strata F142, F58, F64, and F62) (Figure 4 and Figure 5) were chosen for analysis. Storage/pit feature fill included Field Samples (FS's) taken from lower pit fill, 4030 and 4057, and the upper fill, 2097, 4031, 4054, 4056. Occupational surface scrapes included FS's 4294, 4295, and 4375, additionally thermal surface scrapes included FS's 4144 and 4145. Bulk samples included FS's, 33, 35, 64, 2095, and 2096.

TABLE 5  
SUMMERY OF SEED RECOVERY COUNTS

RECOVERY	MOST LIKELY REPRESENTATION	COUNT	PERCENT OF RECOVERY
Large <i>Amaranthus</i> & <i>Atriplex</i>	Sage & SaltBrush	288	70 %
Small <i>Amaranthus</i> or <i>Chenopodium</i>	Amaranth & Goose foot	62	15 %
<i>Poacease</i>	Wild Rye & Rice Grass	42	10 %
<i>Celtis sp</i>	Hackberry	3	1 %
Un-charred <i>Celtis sp</i>	Hackberry	6	2 %
Un-charred	Tansy Mustard	1	< 1%
Un-charred <i>Cactaceae</i>	Cactus	1	< 1 %
Unknown	Unknown	9	2 %

TABLE 6 SUMMERY OF SEED RECOVERY BY CONTEXT			
CONTEXT	RECOVERY	MOST LIKELY REPRESENTATION	PERCENT OF CONTEXT
Bulk Samples	Large <i>Amaranthus</i> & <i>Athriplex</i>	Sage & SaltBrush	66%
	Small <i>Amaranthus</i> or <i>Chenopodium</i>	Amaranth & Goose foot	22%
	<i>Poacease</i>	Wild Rye & Rice Grass	12%
	<i>Celtis sp</i>	Hackberry	0%
Occupational Surface Scrapes (Including Thermal Surfaces) Samples	Large <i>Amaranthus</i> & <i>Atriplex</i>	Sage & SaltBrush	30%
	Small <i>Amaranthus</i> or <i>Chenopodium</i>	Amaranth & Goose foot	70%
	<i>Poacease</i>	Wild Rye & Rice Grass	0%
	<i>Celtis sp</i>	Hackberry	0%
Upper & Lower Pit Fill Samples	Large <i>Amaranthus</i> & <i>Atriplex</i>	Sage & SaltBrush	79%
	Small <i>Amaranthus</i> or <i>Chenopodium</i>	Amaranth & Goose foot	18%
	<i>Poacease</i>	Wild Rye & Rice Grass	0%
	<i>Celtis sp</i>	Hackberry	3%

Several different species were represented in this collection. Disproportionately, most common was the Cheno-ams, which includes Chenopods (inclusive of Sages and Saltbush) and Chenopodium (inclusive of Goosefoot and Amaranth). These were followed by grasses (*Peoseae*), Mustard (*Brassicaceae*), and a few unknowns. The following pie chart shows the relative recovery (Figure 7). In addition to *Agroseris tridentata* (Big Sagebrush) seeds in various stages of maturity, copious amounts of charcoal were present suggesting it may have been used for fire fuel.

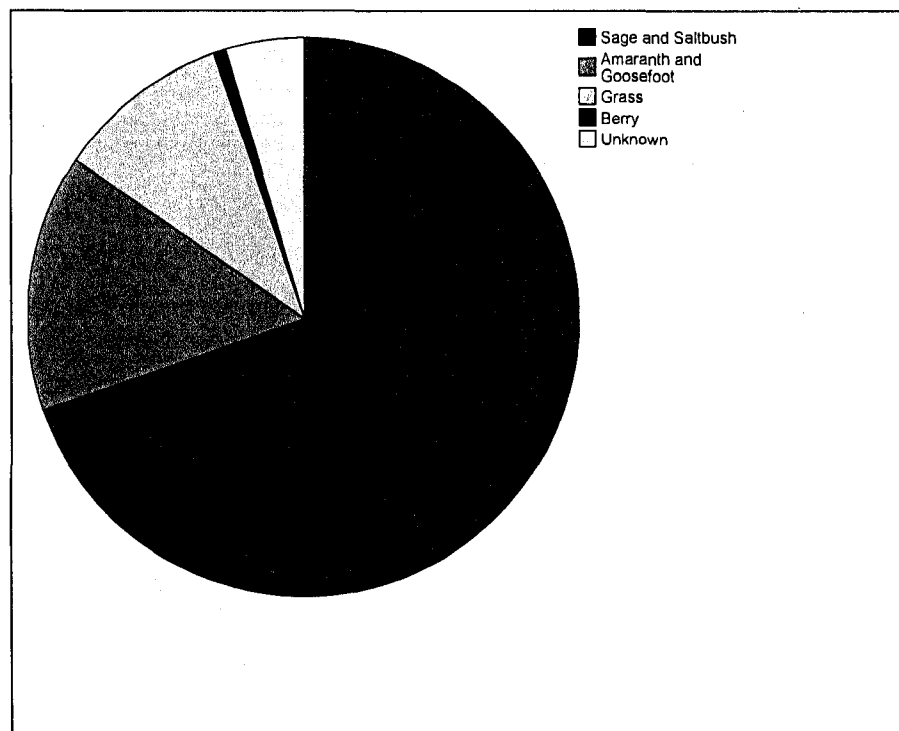


Figure 7: Distribution of Recovered Seeds

## CHAPTER 7

### INTERPRETATION AND CONCLUSIONS

#### Introduction

In order to address the quantitative aspects of Optimal Foraging Theory's cost/benefit analysis, an understanding of resource ranking in terms of caloric properties versus acquisition and processing must be established. The previous chapter discussed ethnographic analogy from appropriate native groups. The Southern Paiutes have given the most significant insight to plant use at North Creek Shelter in terms of the cost/benefits associated with acquisition and processing of plants. Additionally, caloric and nutritional attributes were discussed for the recovered resources.

Many hunter-gatherers, including the Southern Paiutes, practiced a base camp strategy. In this subsistence strategy, foragers occupy a central camp and make daily excursions to exploit the nearby resources (Figure 8). Once an area is depleted, the group moves camp to the next patch, when it is depleted the camp moves again, and so-on.

If relying on Madsen's environmental reconstruction, as described in Chapter 3 and 6, Archaic North Creek inhabitants had reasonably convenient access (i.e., one days foraging or less) to resources discussed in Chapter 6 (for example of similar applications see Simms (1984), for overview see Kelly (1995). In this case, since most resources would have been gathered within the normal daily excursions, travel time would not have been a significant factor differentiating resource choice in Optimal Foraging Theory.

Additionally, most seeds and greens were processed similarly, suggesting that processing did not play a significant factor in differentiating costs between resources of the same class.

Patch models and cost interpretation take into account search strategy. Foraging strategy is expected to maximize the net cost/benefit return. Depending on resource distribution, there are three strategies used by a forager in order to minimize travel costs (Schoener 1971):

- 1) If the distribution of resources is uniform, then systematic swaths back and forth is the most cost effective.
- 2) If the distribution of resources is random, the best strategy is to randomly travel.
- 3) If the distribution was patchy in terms of specific resources, the best strategy would be to travel directly to the highest ranked resources and only collect lower ranked resources if they are in the direct path of the goal.

Under the principles of Optimal Foraging, considering the topography and resource distribution, early Archaic foragers in the Escalante most likely used the third strategy when exploiting plant resources.

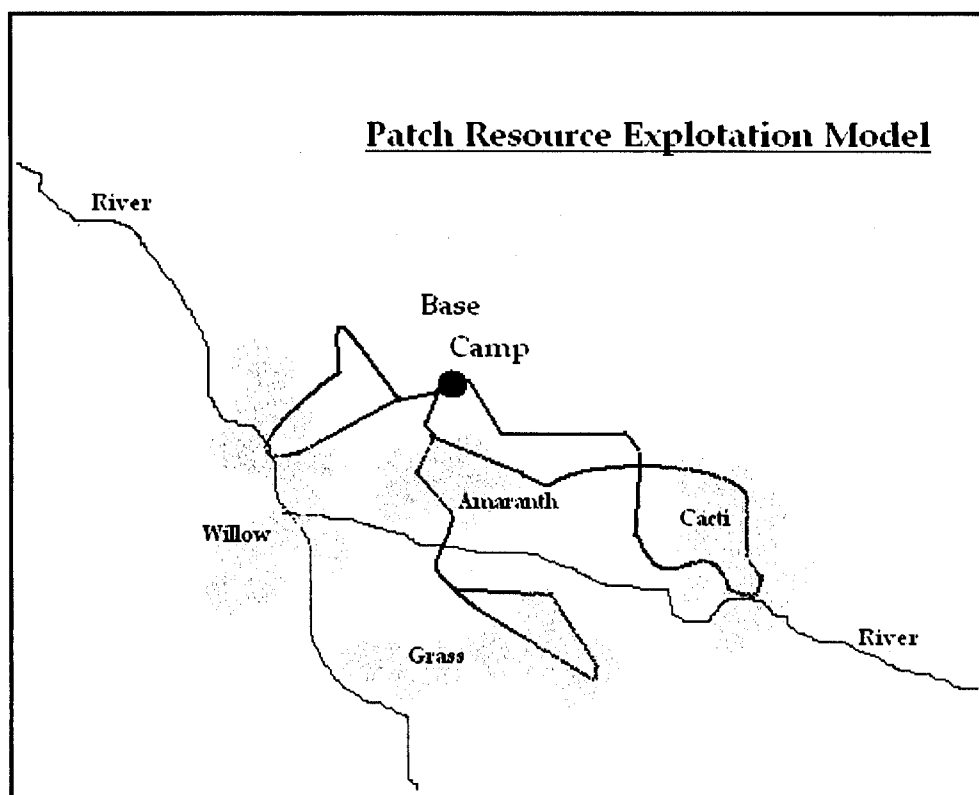


Figure 8: Hypothetical Patchy Resource Exploitation depicting three days of travel rounds from a centralized base camp.

For example, if a healthy 100 pound woman performed her foraging at a pace of two miles per hour, she would burn approximately 110 calories per hour. Thus, any resource that has an acquisition cost of greater than the 110 calorie threshold would have some benefit. In this case, the significant factor in resource rank would be the caloric content of the resource gathered. With this assessment, it is the caloric and nutritional aspects rather than acquisition and processing costs that would differentiate plant resources for the early Archaic foragers under the principles of Optimal Foraging Theory. For this research it will be assumed that this generally holds true. However, there are some exceptions; for example, rice grass is labor intensive to harvest with beaters and trays

(Simms 1987). Additionally, root crops (which are not interpreted in this research due to preservation issues) have higher acquisition costs due to the additional digging labor.

### Resource Ranking at North Creek Shelter

Due to the limited botanical recovery, only seeds will be used for interpretation of Optimal Foraging Theory. It is customary to only evaluate charred seeds as representative of human activities (Minnis 1981). The seeds are a good subject in this research because they come from the same class of botanical resources mitigating unknown factors such as preservation biases.

Of the recovered seeds, Cheno-ams including Sage, Saltbush, Amaranth, and Chenopodium, make up nearly the entire assemblage (Table 5 from Chapter 6, and Table 7). In ranking resources, Saltbush and Sage (71% of recovery) are considered high-ranked resources. Amaranth and Chenopodium (16% of recovery) are considered low-to-middle rank resources (Kelly 1995). A small proportion of grass seeds (*Poaceae*) and Hackberry (*Celtis* sp) were recovered. In general, grasses and berries are low-rank resources due to the acquisition costs (Simms 1987).

High-rank plants such as Tansy Mustard (*Descurainia* spp), Bitter Root (*Lewisia* spp), and Bulrush (*Scirpus* sp.) are not represented in the anthropogenic associated recovery. Unlike Mesquite and Agave complexes which are highly ranked, there is no question that Tansy Mustard, Bitter Root, and Bullrush were widely available during the early Archaic.



TABLE 7 RESOURCE RECOVERY AND RANK BY PERCENT		
RESOURCE	RANK	RECOVERY
Sage and Saltbush	Medium-High	71%
Amaranth & Goosefoot	Medium	16%
Grasses	Low	10%
Berries	Low	1%
Unknown	NA	2%

### Seasonality

Relative to all the botanical resources that were available year-round to the early inhabitants of North Creek Shelter, it appears that the occupants were practicing a mid-rank resource strategy. However, when seasonality is taken into account, there is strong evidence that the occupants were practicing a high-rank resource exploitation strategy.

The highest ranked plant resources that are missing from the assemblage have seeding that is very specific to late summer. Tansy Mustard seeds in the late summer, as do Cattail and Bulrush. Lower ranked items that seasonally seed in the fall such as cacti are missing as well. Root crops such as Cattail and the Lilly family are most nutritious in late summer. Ethnographically these were harvested in late summer for winter storage, additionally they were exploited in the late winter/early spring. Though the cost/benefit ratio of exploiting tubers is not highest in the spring, they often are nonetheless exploited during this season because other food resources (such as small game or stored food) are becoming exhausted. If these resources were being exploited for their roots in the late

summer, we might expect to see uncharred, or inadvertently charred seeds in the assemblage as a byproduct of processing. In fact, only one uncharred Tansy Mustard seed and one possible Cacti seed from the assemblage of over 400 intact specimens. Characteristics from the assemblage strongly suggest that early Archaic North Creek inhabitants were most likely occupying the site seasonally between late spring to mid-summer.

#### Evaluation of Optimality at North Creek Shelter

In evaluating North Creek Shelter Optimality under purely quantitative caloric cost/benefit principles, it is assumed that resources that have a return rate of over 110 calories have the possibility of being an optimal resource. This is because it at least meets the break-even threshold for gathering costs. For processing and other cost considerations ethnographic analogy must be used to make any further inferences.

Ethnographically it is known that Cheno-ams played a significant role in subsistence of proto-historic Southern Paiute groups. The seed recovery from North Creek suggests that this may have also been the case during the early Archaic period. If so, the inhabitants of North Creek were behaving mid-optimally when evaluating the collecting of plant resources.

Seasonality is another very important aspect of the recovery, which suggests that during the early Archaic, North Creek Shelter may have primarily been used in the late spring to mid-summer. Cheno-ams have a broad seeding period that spans from mid to late summer, grasses, too, have a great deal of interspecies variation in seeding. When seasonal plant availability is considered it appears the occupants were exploiting the

highest ranked seed resources available. Thus, under the principles of Optimal Foraging Theory, the early inhabitants of North Creek Shelter were behaving very optimally in their plant exploitation.

With regard to plant use, Optimal Foraging provides an explanation for the plants exploited during the early Archaic (though not evaluated in this research, the implication of adding higher rank game resources is addressed below.) While this may not be the only reason for exploitation, the conclusions of this thesis is that Optimal Foraging Theory's assumptions are a probable explanation for the plant exploitation represented in the assemblage..

Any further conclusions on cost/benefits of this assemblage begin to fall in to speculative inquiries or non-calorically based explanations. Perhaps this is why so many researchers are tempted to broaden the conservative assumptions of cost/benefit analysis to consider alternative and more qualitative evaluations in order to make more fruitful conclusions.

#### Limitations in Evaluation of Optimality at North Creek Shelter

In this research, several factors affect the ability to evaluate Optimal Foraging Theory. First, botanical recovery is limited to seeds. Differential preservation is common to most archaeological sites—North Creek Shelter is no exception. This creates a bias in the macro-plant assemblage toward seeds. Munson (1971: 422) and others explain differential plant preservation in the following terms: “1) those foods which have a rather dense, inedible part, 2) plants which are somewhat dense but which are normally ingested in their entirety (small seeds), 3) non-dense foods with a higher water content

(tubers and greens).” In this case, there is only evidence of those plants that fall into the first and possibly second category.

If Southern Paiute ethnography is an accurate analogy for North Creek, then certainly early Archaic inhabitants were using tubers and greens. Additionally, Isabel Kelly (1964) recorded that the native name for Escalante Valley is Potato Valley. Though she does not report why, this name suggests the importance of root plants. Most tubers are considered medium rank, while greens are generally low-rank on the Optimal Foraging Theory continuum (Kelly 1995). If recovery has created bias, adding these resources may make a significant difference in the evaluation of the overall optimality strategy. Unfortunately, due to preservation there is no way of knowing for certain if, and to what extent, these perishable resources were utilized.

If poor recovery is considered, factors that are complementary to Optimal Foraging Theory may still explain the advantages of resources diversification that utilizes all ranks, i.e., mitigating resource uncertainty may produce a broad-spectrum adaptation rather than a specialized exploitation of only high-rank resources. Unfortunately, there is no other information from the site to evaluate to determine if resource uncertainty would have made broad-spectrum subsistence more optimal in this particular case. For example, there is no evidence of elaborate storage, social stratification, or ritual behavior used to mitigate uncertainty (Rappaport, 1971; Douglas 1966; Radcliff-Brown 1933).

In cases where broad- spectrum subsistence may not be represented in the archaeological record many archaeologists draw on the ethnography and the assumption that similarities in material culture are representative of similar subsistence strategies and perhaps other cultural attributes. At North Creek proto-historic Southern Paiutes are used

for analogy. This is problematic, particularly when looking for appropriate analogies in the Great Basin (Hukell 1998). Even conservative cultures would change over thousands of years; Optimal Foraging provides relief for this problem. If the environment is the same, Optimal Foraging practices will be the same for all groups through time and space.

If such an analogy is productive then another issue becomes relevant. From the ethnography it is known that Southern Paiutes had little regard for the practice of optimality (Knack 2001, Steward 1938). They practiced broad-spectrum subsistence as a combination of palate choice and respect for their culture history (Steward 1938). The first is a personal and the latter is an ideological choice; Optimal Foraging Theory cannot account for either motivation.

Another problem in evaluating optimality is determining how resources were utilized. In addition to ethnographic analogy, archaeological spatial analysis and contextual analysis can contribute information concerning resource use. For example, Bigsage Brush (*Agroseris tridentata*), which comprise a substantial portion of the assemblage, may have been deposited as a result of use as fire fuel rather than a food resource. Evidence for this comes from seeds in various stages of maturity, along with copious amounts of Bigsage charcoal. It is impossible to determine for certain in which context and in what relative proportions Bigsage was utilized for food. In this case it is appropriate to note using Bigsage for dietary analysis may be skewed.

The issues just discussed involve recovery in the archaeological record and the appropriate application of ethnographic plant use at North Creek Shelter. In addition, a more fundamental ethnographic limitation affects the ability to evaluate archaeological application of Optimal Foraging Theory. The problem begins with the historic

ethnographers difficulty providing viable and reliable data for the variables if the cost/benefit equations. Martin (1983: 620) explains that even using averages this becomes difficult, “the analyst usually cannot accompany every individual on every trip....to apportion costs between search and pursuit and among the captured prey.”

In short, the forager is most knowledgeable of quantitative acquisition costs (which are then translated to the ethnographer then to the archaeologist, usually in the form of overall averages) and the archaeologist can only make educated speculation on these observations. Conversely, the archaeologist is best at calculating the quantitative caloric and nutritional aspects concerning exploited resources. Additionally, Martin (1983) argues that the combination of using averages and optimal idealization obscures researchers using optimal foraging models, specifically the dietary breadth model from forming interpretation of motivation from prehistoric contexts. For North Creek Shelter this is a significant disadvantage given the limited ethnographic data and the assumptions that have been made due to lack of robust data.

### Discussion & Conclusions

This research has explored using Optimal Foraging Theory as a middle-range theory. The results have found that using Optimal Foraging Theory as a model has been useful in determining patterns of resource exploitation by early Archaic inhabitants of North Creek shelter. The mid to high ranked botanical assemblage is consistent with the expectations of the Optimal Foraging Theory, and therefore suggests that the early Archaic occupants of North Creek Shelter may have been behaving optimally under principles of Optimal Foraging by exploiting the highest ranked plant resources available during late

spring/early summer occupation. However, because of problems associated with limited plant recovery, this interpretation cannot be considered a thorough evaluation of Optimal Foraging Theory. This evaluation shows that there should be caution in applying Optimal Foraging Theory as middle-range theory to account for resource choice in the very common archaeological context of limited recovery and modest ethnographic information.

This research has additionally explored Optimal Foraging Theory as a high-range theory and concludes that it is inadequate as a theoretical paradigm in evaluating plant use at North Creek Shelter. Generally, Optimal Foraging Theory as a high-range theory lends itself to assumptions that without substantial support of data that can be refuted becomes proverbially self-sustaining. Optimal Foraging Theory requires clear terms in order to avoid promoting a circular argument.

Thus, the largest limitation in evaluating Optimal Foraging Theory as a mid or high range theory for understanding human motivation is a lack of robust data and appropriate ethnographic analogs. Human motivations fall under more complex systems than those proposed by ecologists MacArthur and Pianka, this is exaggerated as a function of a lack of good analogy and keen interpretation with social theory. Without such interpretations, researchers are tempted to reduce human motivation to that of a simple minded foraging animal (Cashdan 1983, after Smith 1983). Without a robust data set and confidence in the application of ethnographic analogy that sees people as more than “foragers,” but rather individuals within a complex cultural system it is impossible to explore the critiques of Optimal Foraging Theory introduced by Shanks, Tilley, and Sassaman (discussed in Chapter 2).

Unfortunately, evaluating the appropriate application has been completely missed by many researchers who use Optimal Foraging Theory. Winderhadler (2001, 13) indirectly notes the contradiction by stating the assumptions of Optimal Foraging Theory; “[there are three criteria necessary for the appropriate application of OFT]: (1) [a]pparent underproduction, and a general lack of material accommodation; (2) routine food sharing; (3) egalitarianism.” For a model based on capitalistic values, these criteria are in contradiction. This logically favors Shanks and Tilley’s, and Sassaman’s assertion of Optimal Foraging Theory’s misapplication discussed in Chapter 2. In fact, Optimal Foraging Theory seems best suited for societies that practice capitalistic social and economic systems. These societies have value systems based on quantifiable variables. Thus some value (i.e. moral) and ideological motivations *may* be measured quantitatively for these societies. Additionally, archaeological assemblages for agricultural and state societies are generally more robust (i.e. more material culture) than those of hunter-gatherers. When applying Optimal Foraging Theory to archaeological assemblages, confining it to agricultural or state societies would be appropriate.

Perhaps the reason Optimal Foraging Theory has not been applied in agricultural and state societies is a result of Optimal Foraging Theory’s development in North America. Following the popular ecological modes, American archaeologists adopted Optimal Foraging Theory. Coincidentally, all of these researches focused on hunter-gatherers rather than state societies. Another factor may have been the lack of hunter-gatherer theory. From the 1940s through the 1980s, many researchers were primarily applying cultural ecology or social evolutionary models, causing innovative researchers to look for a new and more sophisticated theory. It makes logical sense Optimal Foraging Theory would



find a fertile place to develop as a major theoretical paradigm in Great Basin hunter-gatherer archaeology. These founders (e.g., James O'Connell) adopted Optimal Foraging Theory and mentored their protégés to do the same.

#### Avenues for Future Research

In comparison to the overall diet availability, this research suggests that recovered plant resources most closely represent the medium-ranks of the continuum under the principles of Optimal Foraging Theory. When seasonality is considered, the recovery represents relatively high-rank plant exploitation. In this regard, information from North Creek's early Archaic faunal assemblage could be useful. If the faunal remains suggest a late spring/early summer occupation it would support the botanical conclusions of a high optimality botanical exploitation strategy.

Furthermore, while evaluating the plant resources independent of the rest of the paleodiet is a perfectly valid approach, a more inclusive study which evaluates all food resources available to a prehistoric group would allow for further evaluation of Optimal Foraging Theory. Faunal remains (i.e., bone) tend to have better preservation than floral remains. Thus, faunal assemblages are more appropriate when applied to Optimal Foraging Theory models. If Optimal Foraging Theory principles were being used, it would be expected that game in the high-ranked category would be mainly exploited along with flora from the high-ranked category. Following this line of inquiry would give a more holistic view of the entire early Archaic diet. In fact such a project is currently underway.<sup>1</sup>

Gender is another aspect that needs to be addressed. First, if the assumption of plant exploitation is primarily related to women's choices and game to men's, differences in these assemblages may reveal information on gender activities and divisions. Second, Optimal Foraging Theory analyses predominantly portray women as practicing herd and men predator foraging behavior. Both the association of women with plants/herd and men animal/predator imply the western association of women with passive and men with active activities (Watson 1997). However, from the ethnographic record, men, women, and children, are commonly observed in both passive and active exploitation of resources.

Additionally aspects of gender and division of labor could be addressed. The division of labor tends to loosely involve women procuring plants and small game while men procure large and small game—though, caution may need to be exercised in this assumption, as divisions are often fluid (Watson 1997). Based on ethnographic analogy with the Southern Paiutes, a loose division of labor likely holds true for the early Archaic North Creek inhabitants. If true, the botanical research conducted here reflects the pursuits of women in the Archaic society. It has been proposed by many researchers (e.g., Watson 1997) that the foraging motivations for women may be considerably different than those of men. Ethnographically we know that gender roles for hunter-gatherers are flexible and fluid throughout the lifecycle. However, there is one notable exception. Women most often are the primary caretakers of small children. This relationship brings an important dynamic into a mother's foraging behavior. For example it may not be possible and arguably inappropriate to quantify the value of gathering a plant to soothe a colicky child. Another example of an inappropriate application is

evaluating and energy expended by an adult to teach children hunting and gathering skills (Classen 1991). Thus, quantitative measurements of Optimal Foraging would not accurately account for the qualitative benefits of these altruistic interactions between children and their mentors.

Furthermore these issues are not just limited to parent-child interactions. Many researchers propose the “showoff” hypothesis to try quantifiably account for male hunters who spend quantitatively disproportionate efforts in pursuit of game (Bliege and Bird 2000, Smith 2000, Hawks 1993, for overview Buss 2005 and Winterhalder 2001). The presumption is that this phenomena is a result of attempting to increase social status, and thus mating opportunities (Bliege and Bird 2000, Smith 2000, Hawks 1993, Winterhalder 1990, Betzing and Turke 1986, Kaplan and Hill 1985). This assertion may also be flawed. First, altruistic and “showoff” behaviors are qualitative endeavors, attributing a quantitative variable may inappropriate. Secondly, both men and women may or may not perform actions based on quantitative variables such as calories because they do not attribute quantitative values to a qualitative variable such as status. Arguably, there is the phenomenon of performing seemingly costly acts for the sake of developing interpersonal relationships (Winterhalder 2001 and 1990, Kaplan and Hill 1985). Such interpersonal bonds are critically important in small-scale societies, once again however, this may not be for the sole purpose of mitigating risk by creating social bonds to further the success of the group and/or offspring—rather it is conceivable that thesis bond could additionally contribute to higher ideological forms of wellbeing (Knack 2001, Steward 1938).

Considering this, Bennett (1993) gives an alternative to the quantifiable motives in explaining resource acquisition. His qualitative explanation is that values, a moral

process, assigned to environmental resources are not determined by nature, but rather through the dynamics of culture. As Bennett points out, subsistence behaviors alone cannot determine a sequence of events, and needs and desires resulting from social living can occur with or without a relationship to the physical environment. Quantifiable variables would not be helpful in explain human motivation under such circumstances. There are many examples of this deviation from quantitative evolutionary explanations; including the contemporary Southern Paiutes that are pertinent in this research. The contemporary Southern Paiutes have used altruism to maintain and preserve traditional and social ties, despite the onslaught of Euro-American culture (Knack 2001). It would have been easier (i.e., less costly) for Southern Paiutes to adopt western social structure, however respect for social values and cultural history kept most from doing so (Knack 2001, Steward 1938). Social sustainability was clearly important to hunter-gatherers. Behaving altruistically (i.e., quantifiably un-optimally) toward kin, friends, and mates is one way to assure a social sustainably both interpersonally and extra-personally. Thus, altruism functions to improve the quality of life for that purpose alone. The capitalistic assumptions of Optimal Foraging Theory negate this fact when applied to small scale societies (Shanks and Tilley 1987 and elsewhere).

### Summary of Conclusions

Results suggest early Archaic inhabitants of North Creek Shelter were behaving optimally in plant utilization under the principles of Optimal Foraging Theory's predicted high-rank exploitation. Thus, findings of this research are not contradictory to Optimal Foraging Theory, which provide a useful method for predicting and quantifying factors in

resource exploitation. This suggests that Optimal Foraging models may be appropriate as a Middle-Range Theory when evaluating hunter-gatherers with similarities in subsistence strategies to the North Creeks early Archaic inhabitants.

However, Optimal Foraging Theory may not provide the only or wholly accurate account of human motivation. Steward's (1932) and Knack's (2001) ethnographic accounts attribute these exploitation choices to tradition rather than a practical resource mitigation strategy. In essence the qualitative ethnographic accounts of the exploitation of the same plants by an analogous group suggest that optimality is not the motive for exploitation. Thus, this research has found that Optimal Foraging Theory as a theoretical paradigm may not be able to evaluate or account for the qualitative motives for the plant exploitation by North Creek's early Archaic inhabitants.

### Note

1. Collaborative publications are underway authored by Dr. Joel Janetski, Principal Investigator at North Creek Shelter, Brad Newbold, faunal analyst, and me.

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