A GEOSPATIAL ANALYSIS OF PREHISTORIC HUNTING BLINDS

AND FORAGER GROUP SIZE AT COWHEAD SLOUGH,

MODOC COUNTY, CALIFORNIA

A Thesis

Presented

to the Faculty of

California State University, Chico

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Anthropology

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by

Spring 2011

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by

Kevin D. Dalton

Spring 2011

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ACKNOWLEDGMENTS

There is no way that I would have completed this thesis without the help and support of friends, family, and coworkers. I would like to first thank my committee, Dr. Frank Bayham and Dr. Christopher O'Brien. Both Frank and Chris have contributed tremendously to my growth as a professional archaeologist. Frank, as chair, pushed me to focus my study and to look critically at my research and writing. Chris, as a committee member, contributed valuable insight on aboriginal hunting activities stemming from his years of work with the Hadza.

Dr. Antoinette Martinez, Dr. Eric Bartelink, and Dr. Georgia Fox, all deserve a great deal of credit of their patience and support during this long and extensive process. I would also like to thank Penni Borghi, formerly Surprise Resource Area Archaeologist. Penni was instrumental in my return to school to earn my Master's degree and has been extremely supportive of this research.

There are also a number of family and friends that I would like to thank. First and foremost, my parents, for the infinite love and support. Amber, Reno, and Eden, you guys have given me so much support over the years and you are always willing to escape to Redding or Chico for relaxing lunch and a drink in the sun. Finally, I would like to say thank you to all of my Chico family… most of who will never read this.

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ABSTRACT

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Understanding forager social complexity is critical to explaining resource acquisition systems. This thesis will use data from an extensive survey in northeastern California to discuss the geographic placement of prehistoric hunting blinds. Employing a geographic information system, a hierarchical cluster analysis, and nearest neighbor analysis, this study will seek to explain how hunting landscapes are shaped by forager group size and hunting technology. Results suggest that the observed patterning in the spatial positioning of hunting blinds is consistent with expectations derived from foraging theory, and that the spatial placement of hunting features is likely influenced by the performance characteristics of the bow and arrow.

CHAPTER I

THE ARCHAEOLOGY OF HUNTING AND ITS ROLE IN HUMAN HISTORY

It is well known that the natural environment has informed and shaped human action (Steward 1955), and most researchers agree that animal resources have factored prominently into human survival strategies (Binford 1978:23, 1981:xvi; O'Connell 1995:220). However, the extent of which human efforts were driven by local environments, as opposed to social factors (e.g., social status) remains a topic of considerable debate in archaeology (Broughton and Bayham 2003; Hildebrandt and McGuire 2002, 2003). While a great deal of information pertaining to the interaction of humans and animals has been lost to time, there still remains evidence in the form of projectile points, petroglyphs, animal bones, and hunting features, which can be garnered to test hypotheses regarding the nature of these interactions (Bayham 1979; Heizer and Baumhoff 1962; Pendleton and Thomas 1983; Thomas 1981).

Purpose of this Study

This study proposes to apply evolutionary theory to the study of prehistoric archaeological surface features commonly referred to as hunting features. Hunting features will be discussed in detail in later chapters, suffice to say here, they are constructed of organic and inorganic materials for the purpose of directing game animals and concealing hunters. The focus of this study will be on one class of hunting features, stone hunting blinds. Generally, stone hunting blinds features are u-shaped, one to one and one-half meters in diameter, and are constructed of two to three rock courses high. Hunting blinds are a common archaeological occurrence and are frequently noted in cultural resource inventories and the archaeological gray literature.

This study seeks to advance analyses and methods used in the interpretation of hunting features in the western Great Basin. The focus of this study will be on forager task-group (e.g., hunting party) formation and understanding how these groups are reflected in the archaeological record of hunting features. I contend that the distribution of hunting blinds across the archaeological landscape should be an indicator of task-group size, and that the geographic placement of these features should coincide with game trails and migration corridors, and the performance characteristics of Native American hunting technologies.

This study was initiated in the summer of 2006 when the Surprise Resource Area of United States Department of the Interior Bureau of Land Management (BLM) conducted an intensive archaeological survey of a parcel of land recently acquired by way of a land exchange. The author of this thesis was the sole surveyor for the project and author of the North Cowhead Archaeological Reconnaissance Report that followed (Dalton 2007). The survey produced results worthy of note. Several previously undocumented stone features were observed, along with numerous projectile points and petroglyphs. The regularity at which the stone features were encountered raised questions pertaining to their use and distribution.

The research presented in this thesis represents a multidisciplinary approach to the identification and interpretation of prehistoric hunting features. Principles and methods associated with archaeology, biology, geography, geographic information science, and spatial statistics are applied to the archaeological record of the Cowhead Basin in Modoc County, California in an effort to understand the social construction of task-groups and the construction of prehistoric hunting landscapes. The potential results of this research are important in addressing anthropological and archaeological questions regarding prehistoric landscape construction, human hunting practices, and collective foraging strategies.

The Significance of Meat and Hunting in Human History

Many interpretations regarding the early stages of human evolution have suggested that the hunting and scavenging of animals factored prominently into human survival (Isaac 1978:117). The ability to secure calorie rich animal resources offered certain nutritional advantages to hunters and the individuals who were reliant on their spoils (Issac 1978:112, 122). That said, the addition of meat in human evolution remains a controversial and highly debated topic in anthropology, although it is well accepted that the road to encephalization and modern humanity began with an interest in the consumption of meat (Bunn 2007:205, 217).

Hunting and its associated behaviors are considered to be evolutionary characteristics of modern humans (Hayden 1981:416). The archaeological record of hunting technologies and cave art created by early humans stands as a testament to the importance of animals resources to the human diet (Mithen 2003:3,123). Animals factor so prominently in human survival that the pursuit of uncharted hunting grounds has been cited as the impetus for the discovery of North America about 11,500 BP (Grayson and Meltzer 2002:314; Martin 1973; Meltzer 2009:9).

As human populations expanded into new territories, a diet based primarily on the hunting and capture of animal recourses would have likely been a better-suited subsistence strategy than one constructed around plant remains (Kelly and Todd 1998:234). Movement into new environments and changing climates likely resulted in exposure to new plants whose edibility would have been unknown to early explorers. Exposure to new plants would possibly required the development of new technologies in order to process them to the point of edibility. In addition, climatic variation could even lead to unpredictable fruiting of plants known to be edible (Kelly and Todd 1998:234).

A fundamental knowledge of animal behavior could be easily be transferred across environments, and with the appropriate technology hunting could effectively take place anywhere at any time (Kelly and Todd 1998:234; Mithen 2003:139). For the most part, animals would be broadly dispersed across the natural landscape and obtainable year-round. The anatomical similarities of many animals also made their processing and preparation much easier than those associated with plants. A hunter that could kill and butcher a bison, could without difficulty do the same to an elk, deer, or rabbit (Kelly and Todd 1998:234).

The initial inhabitants of North America have generally been characterized as hunter-gatherers specializing in the capture of late Pleistocene megafauna (Martin 1973:969). While this view is not without its critics (Grayson and Meltzer 2002:313), the majority of researchers accept that the first Americans killed megafuana on occasion, with the bulk of their diet comprised of a variety of game animals (Waguespack and Surovell 2003:334). There is no question that the quest for animal resources factored prominently into the settlement of North America.

Animal bones found in association with archaeological material comprise the most unequivocal evidence for the exploration of animals for human subsistence (Thomas 1969:392). The Great Basin faunal record provides a clear indication that hunting and animal resources played a significant role in the lives of hunter-gatherers inhabiting the region (Byers and Broughton 2004; Thomas 1969; Wolverton 2008). Animals such as bighorn sheep, mule deer, pronghorn, black-tailed jackrabbit, and cottontail rabbit comprised the majority of protein within the prehistoric diet (Fowler 1986; Kelly 1932; Riddell 1960; Steward 1938; Stewart 1939). In addition to their nutritional value, animal remains provided raw material for manufacture and select portions were utilized in medicine and ceremony (Fowler 1986:97).

Apart from faunal remains, stone hunting features represent one of the only artifact categories that directly links the contemporary archaeological landscape to prehistoric hunting practices. In the Great Basin large game were frequently captured through the construction and use of blinds, corrals, pits, and fences (Fowler 1986:79). It is my opinion that the study of archaeological stone hunting features holds the potential to address many behavioral questions regarding the actions of prehistoric Great Basin hunters.

Research Question

Across the disciplines of archaeology and anthropology questions regarding human subsistence, aboriginal technology, and the sustainability of human populations endure. These lines of inquiry are fundamental to understanding the prehistoric past. This study will utilize evolutionary theory, ethnoarchaeological data, and modern and ethnographic accounts pertaining to hunting, in conjunction with archaeological data in an effort to contribute new insight into these longstanding avenues of research. Through the integration of traditional forms of archaeological data with modern tools for data analysis I hope to explain the following question: to what extent are hunting landscapes shaped by forager group size and hunting technology? While there are a number of geographic regions that would likely suit this research, I have selected the Cowhead Basin as the site for this study.

The hypothesis of this study is that prehistoric hunting strategies were shaped by a forager's drive to maximize their caloric intake. From this perspective, the forager would employ the most energy and time efficient methods possible to capture the highest ranking animal resources available. To thoroughly investigate this hypothesis it will be necessary to review the theoretical perspective of evolutionary ecology, the anthropological and archaeological literature pertaining to the Great Basin, and prehistoric hunting. Additionally, I will complete an archaeological record search at local repositories.

Organization of Thesis

This chapter has introduced the premise of this study, and established the archaeological context under which this study takes place. It has also set forth the research question from which the analytical portion of this thesis will be based. However, it has only briefly alluded to the theoretical orientation motivating this research.

Chapter II will set the theoretical stage for this study. It will provide an overview of evolutionary ecology, behavioral ecology, foraging theory, and the optimal group size model. Chapter II will also demonstrate the value of foraging theory in understanding prehistoric subsistence and settlement in the Great Basin, and indicate the Great Basin's subsequent role in understanding forager group size and the prehistoric pursuit of large game.

Chapter III will provide archaeological and ethnographic evidence in support of the relationship between archaeological stone features and large game hunting in the prehistoric Great Basin. It will discuss other archaeological data commonly associated with hunting activities, and demonstrate that the creation and maintenance of hunting landscapes represented a considerable economic investment by Native Americans. In addition, Chapter III will present examples of ongoing archaeological research in the northwestern Great Basin in order to demonstrate the quality of research in the region.

Chapter IV will provide an introduction to the environmental context of the Great Basin and the Cowhead Slough study area. It will illustrate the suitability of the regional environment for large game and expand on the discussion from Chapter I concerning the importance of large game to the Native American people. The final goal of Chapter IV is to explain the archaeological fieldwork and data collection process at Cowhead Slough.

Chapter V will summarize the analytical methodology utilized in this study and present the results of the research. The goal of Chapter V will be to introduce the field of spatial point analysis, define a graphic information system, and discuss the three analytical methodologies utilized in this research: hierarchal cluster analysis, spider analysis, and nearest neighbor analysis. The summary and conclusion will be provided in Chapter VI.

CHAPTER II

EVOLUTIONARY ECOLOGY AND ARCHAEOLOGY

Studies in evolutionary ecology are foundational to our understanding of prehistoric hunting and human subsistence in the Great Basin (Bayham et al. 2011; Beck 2008; Broughton and Bayham 2003; Broughton et al. 2008; Broughton and Grayson 2003; Byers and Broughton 2004; Byers and Ugan 2005; Grayson and Cannon 1999). Fundamental to these studies are issues pertaining to prey selection, diet breath, time efficiency, and group size.

This chapter will review the general theoretical approach of evolutionary ecology and will provide an overview of foraging theory and the models of optimality contained therein. The goal of this chapter is to develop an expectation regarding the clustering of prehistoric hunting blinds based on optimal group size model. This expectation will later be tested against the archaeological record. Factors influencing forager group size, such as reproduction and social learning, will also be discussed. The review of evolutionary ecology given here will demonstrate how this perspective exhibits a strong theoretical coherence resulting from its theoretical alliance with economics and evolutionary theory. This chapter will also show how archaeological applications of evolutionary ecology successfully address questions pertaining to prehistoric foraging decisions.

Evolutionary Ecology

Evolutionary ecology is defined as, "…the application of natural section theory to the study of adaption and biological design in an ecological setting" (Winterhalder and Smith1992:5). This perspective emerged in the 1960s in conjunction with the processual movement in American archaeology. Processual archaeology was movement away from the static thought of the culture historical approach towards an "evolutionist, behaviorist, ecological, and positivist approach" (Trigger 2006:386). Lead by Lewis Binford and the New Archaeology, archaeologists began collecting data on ecology and settlement patterns. Proponents of the New Archaeology set out to redefine the goals of archaeology; they believed that the goal of archaeology should be to explain the complete range of variation in cultural behavior (Binford 1962:217, 1980:4). In other words, evolutionary ecology addresses questions related to the structural and behavioral traits of organisms and the interaction of organisms within their ecological communities (Smith and Winterhalder 2003:378; Winterhalder and Smith 1992:13). Cultivated in studies of animal behavioral ecology, evolutionary ecology has become a primary tool for anthropologists who use this theory to understand human behavior (Smith and Winterhalder 2002:14).

Central to evolutionary ecology is the neo-Darwinian principle of natural selection (Kennett 2005:11; Smith and Winterhalder 2003:379). The Darwinian theories applied in this research are those that address macro level trends; they are the cumulative product of behaviors, which can be inherited genetically, and learned culturally or socially (Bettinger 1991:151; Cannon and Broughton 2010:4). Neo-Darwinian approaches stress the importance of the individual in society; they assume that individuals formulate decisions out of self-interest in an effort to maximize their selective or reproductive fitness (Bettinger 1991:152). In other words, beneficial behaviors (those behaviors selected for genetically or culturally) should increase individual reproductive fitness.

Studies in evolutionary ecology contribute to our understanding of the decisions and behaviors that result in the tangible remains of culture (Binford 1980:4). When applied to archaeology evolutionary ecology offers an evolutionary perspective to understanding the material culture of the human past. The archaeological applications of evolutionary ecology by and large focus on how social-environmental conditions shape human behavior, and how environmental variability influences the variability observed in the archaeological record (Cannon and Broughton 2010:1, 2).

Behavioral ecology, also commonly referred to as human behavioral ecology, is a subfield of evolutionary ecology that addresses questions related the adaptiveness of human behavior (Cannon and Broughton 2010:1). The behavioral ecology sub-field has been referred to as the sub-field "…most directly applicable to the study of the archaeological record" (Cannon and Broughton 2010:1).

Behavioral ecology is the study of evolution and the adaptive nature of human behavior within various ecological contexts (Kennett 2005:11). It employs theory and method cultivated in evolutionary biology to illuminate aspects of human behavior (Smith and Winterhalder 2003:378). Similar to other explanatory approaches it relies on a number of ideas developed within different academic disciplines.

The early goal of research in behavioral ecology was to place Julian Steward's theory of cultural ecology, particularly its application to hunter-gatherer societies, on firm theoretical ground by associating it with neo-Darwinian approaches for understanding human behavior (Winterhalder and Smith 2000:51). Behavioral ecology differs from cultural ecology because of its emphasis on individual behavior and the evolutionary processes of selection as the two main forces that shape human societies. In this sense, "...behavioral ecology provides the evolutionary and adaptive mechanisms (evolution by natural selection) that were often missing in cultural ecological studies" (Kennett 2005:12).

Today, research in behavioral ecology is known for its methodological and quantitative research approach. When compared to socio-cultural anthropological research methods, the structure of behavioral ecology exhibits a strong coherence that results from its theoretical union with economics and evolutionary theory (Winterhalder and Smith 2000:51). At the heart of behavioral ecology is a refined and flexible set of explanatory models that can be tested against archaeological data. Studies grounded in behavioral ecology tend to focus on three themes: production and resource acquisition (Beck 2008; Byers and Ugan 2005), reproduction and life history (Borgerhoff 1992; Voland 1998), and distribution and exchange (Orth 1987; Smith and Bliege Bird 2000).

Foraging Theory

Behavior consumes two key resources, time and energy (Cuthill and Huston 1997:97). The fact that a forager's time and energy cannot be allocated to all behaviors at all times is fundamental to evolutionary ecology. Foragers must weigh their decisions and make trade-offs in order to best utilize their time and energy. The most direct tools for examining behavioral trade-offs are models of optimality (Cuthill and Huston 1997:97).

Models of optimality have an economic aim. They allow for researchers to be explicit regarding the nature of trade-offs and to investigate their putative impact on behaviors (Cuthill and Huston 1997:97).

Foraging theory is a subset of human behavioral ecology. Its methods have inspired the collection of large quantities of data relating to resource acquisition cost in relation to its dietary payoff (Bird and O’Connell 2006; Broughton and Grayson 1993). Foraging theory suggests that during foraging activities individuals should strive to maximize the net intake of resources in relation to the energy expended during acquisition. When directly taken from the concept of natural selection, models within foraging theory argue that “direct and indirect competition for resources gives advantages to organisms that have efficient techniques of acquiring energy and nutrients” (Winterhalder 1981:15). According to Pyke and colleagues (1977:138), foraging behaviors will show heritable variation, however a forager can alter its prey encounter rate by changing its own behavior. Superior resource acquisition techniques developed by individual foragers are transformed into measures of survival and reproductive fitness (Winterhalder 1981:15).

The growth of foraging theory in anthropology has relied heavily on ethnoarchaeological research. Ethnoarchaeology is “the study of contemporary peoples to determine how their behavior is translated into the archeological record” (Thomas 1998:273). This anthropological sub-field also began in the 1960s with the rise processual archaeology. The processual framework stressed that an understanding of the archaeological record began with a firm understanding of site formation processes (Schiffer 1972). This involved explaining how the archaeological record is formed through the development and application of "…models, theories and laws" (Schiffer 1972:156). Ethnoarchaeology offered archaeologists a forum in which they could accomplish the goals set forth by the processual movement.

Processualist archaeologists thought that because of the high degree in the regularity of human behavior much could be gained through the application of ethnoarchaeological methods (Binford 1978, 1980). Through middle-range theory, they proposed that once links between archaeological context and mode of production (e.g., behavior) were realized, hypotheses addressing "the composition of task groups, their means of recruitment… how they [were] structured within the total system organization, and… how these organizations change[d]," could be formed and tested (Schiffer 1972:163). The identification of patterns in human behavior to address site-formation processes, economic and social identifiers, family and community structure, and political relations was used to establish a correlation between the material remains observed in an ethnoarchaeological context and materials recovered archaeologically (Trigger 2006:399).

Within foraging theory even the simplest questions such as, when an animal should feed requires a careful analysis of and comparison with a number of other behaviors. The goal of feeding is to provide nourishment and allow for growth and reproduction (Cuthill and Huston 1997:101). There are two categories of costs associated with food, those relating to its acquisition and those associated with the care of it once secured (Cuthill and Huston 1997:105). Acquisition costs, such as pursuit time are inherent to the foraging process (Stevens and Krebs 1986:7). Costs associated with the care and maintenance of food are generally considered to be those relating to the processing, transport, and storage of the energy reserve (Lindström 2007:232).

Models of Optimality

Models within foraging theory deal with how foragers search for, encounter, and handle prey (Martin 1983:615; Stephens and Charnov 1982:251). It is generally accepted that the most sensible measure for foraging efficiency is the maximization of net energy intake, because it accounts for "…energy maximization over a fixed time and time minimization to a fixed energy gain" (Stephens and Charnov 1982:261). In other words, food is not evenly distributed across the natural landscape, it is found in clumps or patches. A forager incurs energetic costs when traveling to and from patches, therefore the forager must carefully weigh to the costs and the benefits associated with movement. From this perspective, choosing when to forage in a patch and when to travel to a new patch becomes a major energetic decision (Charnov 1976:129).

Models are simplified versions of complex realities. They allow insight into how the components of a problem interact and facilitate comparisons of conditions and assumptions (Stephens and Charnov 1982:262). Foraging models are generally comprised of three components: decision assumptions, currency assumptions, and constraint assumptions (Stevens and Krebs 1986:5). The decision component of a model considers the choice an animal would make in a given situation. A model's currency assumption compares the options related to the decision variable. The constraint assumption refers to the factors that limit and define and the relationship among the decision and currency variables (Stevens and Kerbs 1986:6-10).

The application of a number of optimality models to understanding prehistoric foraging strategies has proven profitable within the field of archaeology (Broughton 1994; Byers and Ugan 2005). Models frequently used in foraging theory incorporate the use of such variables as: patch choice, diet breath, prey choice, pattern of movement and speed of movement, settlement, allocation of time, and group size (Martin 1983:615-624; Pyke et. al 1977:141-149).

The focus of this study will be on models pertaining to the allocation of time, group size, and prey choice. These variables play a vital role in shaping the behaviors associated with the acquisition and maintenance of food resources among foraging populations.

Prey Choice Model

The prey choice model "…asks whether a forager should attack the item it just encountered or pass it over" (Stevens and Krebs 1986:13). When foraging an animal continually repeats the same sequence; they search, encounter, and decide to pursue until a successful outcome is achieved (Stevens and Krebs 1986:13). By and large there are four well-accepted assumptions associated with the prey choice model. First, prey items are ranked according to their overall caloric return per energetic investment (Pyke et al. 1977:141). Second, prey items are added into the diet according to rank (Pyke et al. 1977:141). Third, lower ranking prey items are incorporated in the diet not as a function of their own abundance on landscape, but in relation to the abundance of higher ranked items (Pulliam 1974:65). Fourth, the highest ranked prey item should always be pursed when encountered (Pulliam 1974:66).

Given the assumptions of the prey choice model high ranking large game (e.g., artiodactyls) should be more regularly hunted and subsequently pursued whenever encountered. Thus, in the case of prehistoric human foragers there should be substantial archaeological evidence in support of the hunting and capture of large game when these resources are available.

Time Allocation, Movement, and Central Place Foraging

Movement patterns and time allocation among foraging animals has received considerable attention in evolutionary ecology (Bayham et al. 2011; Beck 2008; Broughton 1994, 2002; Charnov 1976; Grimstead 2010; Kelly 200; Pyke et al. 1977; Stevens and Krebs 1986). In some instances, prehistoric foragers likely traveled considerable distance to secure high-ranking prey items. The central place foraging model (Orians and Pearson 1979) accounts for this distinct foraging strategy. When a forager repeatedly voyages from and then returns to a central locality or a home base, they are regarded as a central place forager. Pursuit time, time spent preparing the resource for transport, and travel time all factor prominently into logistical decisions regarding foraging and hunting and the central place foraging model. The central place foraging model is closely related to the prey choice model and resource patch selection.

In general, a forager practicing a central place foraging strategy will expend energy over three periods: the trip away from the home base, while foraging, and the return trip (Orians and Pearson 1979:156). As the forager ventures farther from the home base the energy reserve collected must also increase to offset the greater travel costs incurred (Orians and Pearson 1979:167). Resource patches occur at varying distances from a forager's home base and a specific prey item's rank within these patches also varies in relation to the distance a forager must travel to secure the resource (Orians and Pearson 1979:166).

Overtime, the area surrounding a home base becomes depleted of high ranking prey items and the forager must then venture further to secure resources. This phenomenon is known as resource depression (Charnov et al. 1976). As the distance traveled increases the forager begins to incur greater travel, transport and associated field processing costs (Smith and Winterhalder 1992).

The expectations derived from the central place foraging model suggest that if a forager makes a significant travel investment to utilize a specific resource patch, the forager should pursue the highest ranked resource available at that patch. Subsequently, the distance traveled also factors highly into the forager's field processing and transport decisions. It is likely that as the distance from a home base increased so would the forager's tendency to forage as a member of a group. Thus, increasing foraging success rates, and the capacity for transport of the resources back to the home base.

Group Size Theory

The animal tendency to create social groups is well documented in the evolutionary literature. Research utilizing group size theory suggests that social groups form for a variety of reasons including: ecological (Caraco and Wolf 1975), reproduction and child protection (Courchamp et. al 2002), threat vigilance (Bertram 1980), and foraging activities (Schmidt and Mech 1997). And, as you might expect, foraging behavior is often closely correlated with group size.

Analyses of optimal foraging group size must use evolutionary currencies that accurately depict foraging success. Traditionally, the currency deemed most appropriate for measuring foraging success has been daily per capita food intake (Creel and Creel 1995:1325). However, it is important to remember that the per capita food intake measure of foraging success does not take into account many of the costs associated with hunting, such as pursuit time, the defense of captured prey, sharing, and social learning (Cooper 1991:131, 134; Creel and Creel 1995:1334).

Communal hunting is conspicuous among larger carnivores, and associations between hunting group size and prey size are common with these predators. Larger hunting groups facilitate the capture of larger prey items and successfully increase both hunting success and captured prey mass (Carbone et al. 1997:318).

The results of two studies of African wild dog packs in the Selous Game Reserve in southern Tanzania suggest that there are substantial fitness benefits for African wild dogs that hunt in groups comprised of between 12 to 14 adults (Creel 1997:1322; Creel and Creel 1995:1334). This optimal hunting group size is slightly higher than the observed hunt mean of ten adults (Creel 1997:1322). However, the authors note that most hunting parties are highly coordinated, with group members participating in "… an intense greeting ceremony or rally just prior to hunting" (Creel and Creel 1995:1331). This high level of cooperation may facilitate smaller group sizes with increasing returns.

Optimal Group Size Model in Anthropology

The of role that social groups play among forager populations has been a topic of interest in anthropology and its subfields for over seventy five years (Birdsell 1968;

Steward 1936, 1955; Woodburn 1972). At the heart of these studies were questions pertaining to cooperation, food sharing, and the dissemination of information. More recently, models developed within foraging theory have become the catalysts to hypothetico-deductive research addressing the social grouping of hunter-gatherers (Smith 1991:1).

John Martin (1973) provided one of the seminal works on optimal group size. His premise was that the construction of seasonal task groups would reflect the number of individuals needed to efficiently execute the primary task for which the group was assembled (Martin 1973:1460). Martin used ethnographies focused on the western Pai (Hualapai) of what is now northwestern Arizona. He discussed the tendency of the Pai to form seasonal task groups that number about 25 individuals. Martin determined that the central focus of these task groups was to hunt large game, primarily deer. Hunting parties were founded on four experienced male hunters. The remaining 21 or so individuals in the group would consist of the hunter's wives, dependent children and dependent individuals (Martin 1973:1464).

The optimal group model (Figure 1) within foraging theory addresses the relationship between group size and per capita caloric return rates (Kelly 1992:92; Smith 1991:293). I will employ this model in later chapters to study the spatial distribution of prehistoric hunting blinds.

The model suggests that when the per capita return rate reaches a maximum return output (shown as RO), existing members of the group will receive the most return for their energetic input. This maximum return occurs at the optimal group size (Smith 1991:298). From this point the group will suffer a decline in individual returns as

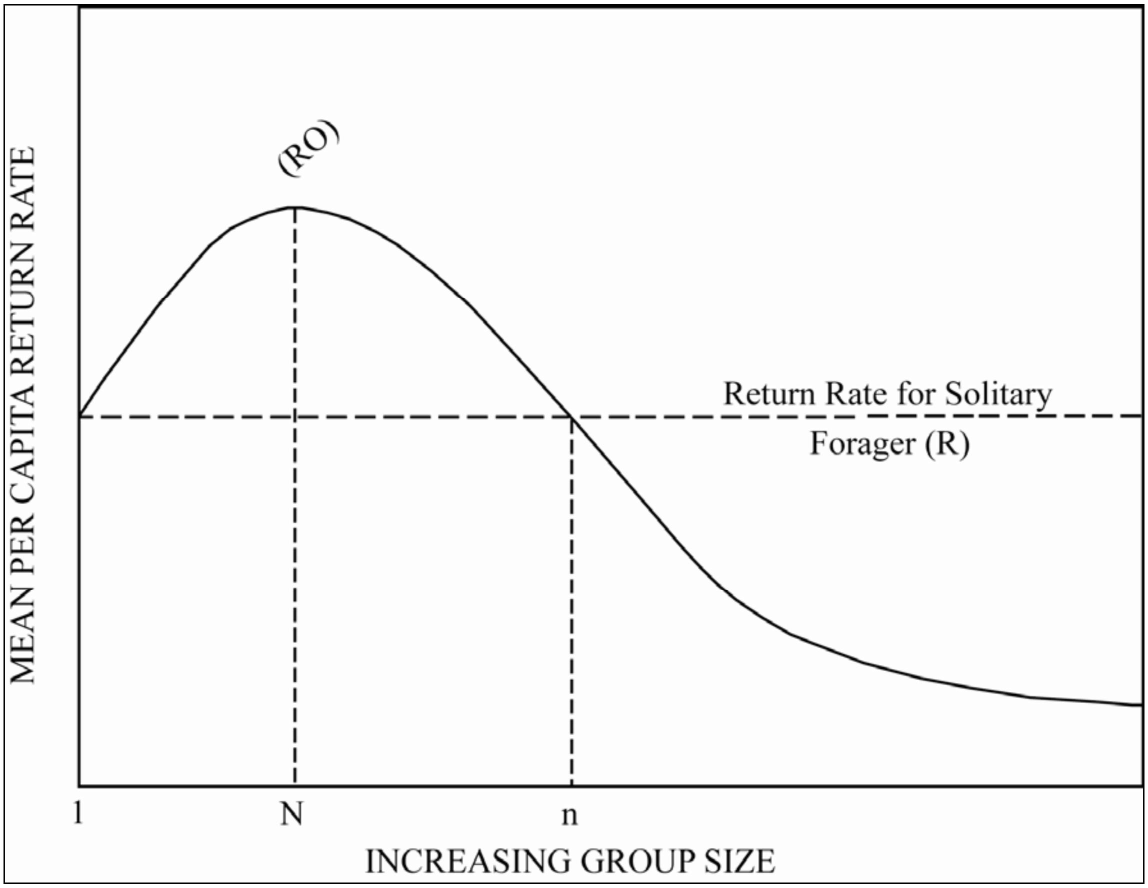

Figure 1. Optimal group size model.

When the per capita return rate (R) reaches a maximum return output (RO), which occurs at the optimal group size (N), existing group members will receive the most return for their energetic input. From this point (N) the group will suffer a decline in individual returns as additional members join. The existing members will tolerate joiners, as long the return rate (R) remains above returns which a forager could achieve through solitary production once the group size increases beyond the hunt type maximum (n), members will separate from the group to forage independently or form new smaller groups

Source: Adapted from Kelly, R. L., 1992, *The Foraging Spectrum*. Smithsonian Institution Press, Washington, D.C.; Smith, E. A., 1991, *Inujjuamiut Foraging Strategies*. Aldine de Gruyter, New York; Smith, E. A., and B. Winterhalder, 2003, Human Behavioral Ecology. In *Encyclopedia of Cognitive Science*, Vol. 2, edited by L. Nadel, pp. 377-385. Nature Publishing Group, London.

additional members join. Existing group members will tolerate joiners, as long the return rate remains above returns a forager could achieve through solitary production (shown as

R). Once the group size increases beyond the hunt type maximum (shown as n), members will separate from the group to forage independently or form new smaller groups (Smith and Winterhalder 2003:380; Winterhalder and Smith 2000:54). The forager's attempt at maximization leads to a number of the short-term resource acquisition choices. These short-term choices often lead to the formation of social groups, which "…provide the context for complex social dynamics" (Smith and Winterhalder 2003:380).

The selective forces influencing group formation and social interaction are multifaceted, offering many advantages and disadvantages to foragers. Advantages include greater per capita foraging returns and diminished return rate variation. The disadvantages to group foraging stem from social agents (e.g., joiners and learners) and environmental factors such as greater local resource depression (Broughton 2002; Smith 1991:350). The most common factors influencing foraging group size are the training of young foragers, companionship, and the ability of additional to aid in field processing and transport (Smith 1991:350).

Eric Alden Smith's ethnoarchaeological studies among the Inujjuamiut of Canadian arctic applied evolutionary ecology and the optimal group size model to explain the particulars of modern arctic foraging (Smith 1991:3). His initial study centered on the relationship of foraging group size and its relation to caloric returns (Smith 1981). This study exemplified how foragers organized into specific groups produce substantially high caloric returns when foraging at or near optimal group size, as predicted by the optimal group size model. Inuit groups organized to hunt caribou produced the highest caloric returns second only to seabird netting hunts. The sample size for caribou hunts was nine, with a mean of four individuals per hunt. Peaks in caloric returns occurred in hunting groups comprised of three and five individuals, and hunting group size ranging from one to seven individuals (Smith 1981:59). The results showed a moderate linear correlation among the expected foraging party size and that of Inujjuamiut foragers. Smith concluded that there was a meaningful relationship between foraging group size and energy efficiency (Smith 1981:64)

Inujjuamiut Foraging Strategies (Smith 1991) reviewed and classified the contemporary foraging practices of arctic hunter and gatherers. Over the course of a year the Inujjuamiut participated in nearly thirty different hunt types, ranging from netting fish and collection seabird eggs to hunting whales and caribou (Smith 1991:159-160). One classification of hunts made by Smith was terrestrial Hunts (Smith 1991:165). Terrestrial hunts included any hunting activity undertaken from land; the Inujjuamiut fished with rods and nets, pursued goose, trapped fox, and traveled large distances to hunt caribou (Smith 1991:165-169). Caribou were hunted intensively from December to March when the animals were concentrated on winter ranges; however they were taken whenever encountered regardless of the specific goal a particular hunt. Winter caribou hunts were usually three days long and involved traveling about 65 kilometers inland (Smith 1991:165). The hunting parties were formed prior to departure minimizing the potential for joiners or uninvited individuals to adhere to the group (Smith 1991:334).

Smith’s data on hunting group size and caloric return rates for caribou hunts exhibit considerable variation, which may be the result of the sample size (Smith 1991:334). Caribou hunt results show that foragers achieve the greater returns from groups comprised of between three and seven individuals. Groups of three and five were model with the highest caloric return rates occurring at groups comprised of six to seven individuals (Smith 1991:335). These data do not necessarily support the hypothesis of group size optimization, however given the amount of noise they exhibit it is reasonable to suggest that a larger sample size would offer such support (Smith 1991:334). At minimum Smith's data illustrates that large groups fair better than small groups when pursing large game.

The evolutionary ecological theoretical framework provides a substantial tool for addressing questions pertaining to foraging societies. It is through the study of contemporary forager populations that ethnoarchaeology has helped paint a more complete picture of the site formation process; it is responsible for much the growth of foraging theory, refining existing models of optimality, while spurring the developing new ones.

Clustering of Hunting Blinds

The groundwork laid by Martin (1973) and Smith (1981, 1991), and the critiques that followed (Martin 1983) have transformed studies of human foraging. Research utilizing the optimal group size model indicates that foragers form non-random task specific groups comprised of skilled individuals. The question is no longer "…whether foragers should hunt individually or communally, but what is the optimal size of a foraging party" (Kelly 1992: 218)?

The optimal group size model assumes that foragers will pursue resources in numbers that optimize their caloric returns. Previous research utilizing the optimal group size model has shown that when hunting large game, hunter-gathers will forage in groups comprised of from four to seven individuals (Martin 1973; Smith 1981, 1991). In this study, I contend that the archaeological record of stone hunting blinds in the western Great Basin will reflect forager hunting party size. Therefore, I expect hunting blinds in the study area to cluster in numbers consist with those derived from the optimal group size model. In other words, hunting blinds in the study area will occur in groups comprised of four to seven features. It is logical to expect that humans hunt cooperatively and that hunting blinds will correspond to optimal group size. I am making the assumption that a single individual occupied each hunting blind, and that some of the blinds within a given cluster was occupied contemporaneously.

When hunting collectively foragers commonly employ chasers. Chasers are individuals that seek out game animals and drive them toward other members of the hunting party who are stationed at the hunting blinds. The use of chasers is frequently noted in the ethnographic literature. However, there is no way to account for the use of chasers archaeologically. The chaser effect has no bearing on the configuration of hunting blinds and therefore is inconsequential to the results of this study.

Chapter Summary

This chapter has demonstrated that evolutionary ecology is a cohesive theoretical approach stemming from biological selection. It has conveyed the importance of applying foraging theory in the Great Basin to better understand prehistoric subsistence and settlement, and it has shown that the Great Basin is an appropriate and productive location to pursue evolutionary ecological research pertaining to prehistoric group size and the pursuit of large game. Most importantly this chapter has utilized the optimal group size model to derive an expectation for the clustering of hunting blinds on the archaeological landscape. This study contends that hunting blinds will occur in cluster that consist of from four to seven features.

CHAPTER III

LARGE GAME HUNTING IN THE GREAT BASIN

Native peoples of the Great Basin have relied on animals for subsistence for over ten millennia. Since the focus of this study is on understanding forager decisions regarding the hunting of large game and interpreting how these decisions manifest in the archaeological record of the western Great Basin a review of the relevant anthropological literature is needed. This chapter will provide such a review and illustrate how the Great Basin is ideal for exploring evolutionary ecological questions pertaining to forager group size. In all, this chapter will illustrate the suitability of hunter-gatherer archaeology in the Great Basin, and exemplify the regions value to the evolutionary ecology theoretical framework.

The summary and discussion of the ethnographic documentation provided in this chapter garners historical support for large game hunting and group hunting by Native American people inhabiting the Great Basin. The archaeological overview will demonstrate that stone hunting blinds occur archaeologically throughout the Great Basin, and are frequently associated with hunting activities. This chapter will then discuss Native American hunting technology. The goal of this chapter is to develop an expectation for the optimal spatial placement of hunting blinds based on the optimal performance characteristics of Native American hunting technology.

The North American Great Basin

Countless anthropological researchers have seen value in the North American Great Basin (Figure 2). The cultures of the basin and their material remains have been extensively studied since the inception of American anthropology, and research in the region has resulted in several important theoretical developments, such as Steward's theory of cultural ecology (Steward 1995).

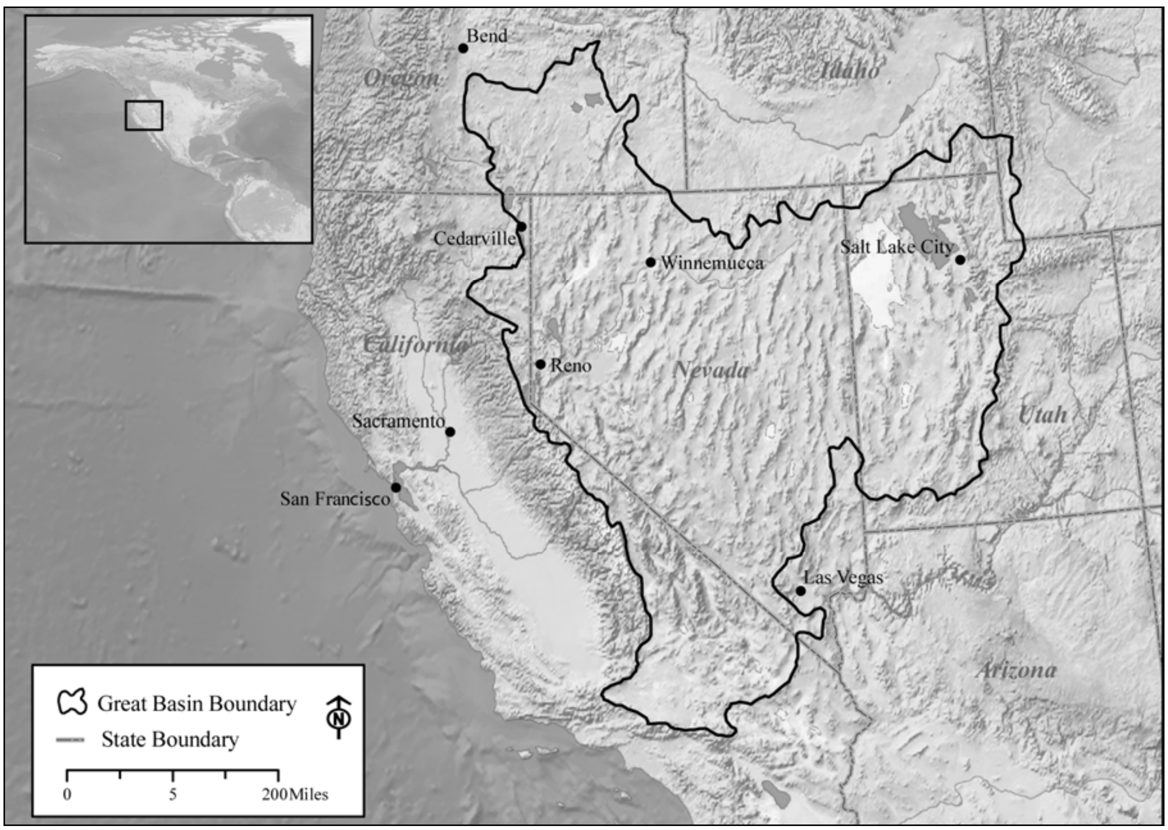

Figure 2. Topographic map illustrating the boundaries of the North American Great Basin.

Source: Data set for map from Natural Earth, 2011, Free Vector and Raster Map Data. Electronic document, http://www.naturalearthdata.com/, Accessed February 2, 2011.

The Great Basin is generally considered to be an arid desert. It is most commonly defined as a single hydrographic unit draining much of the western United

States internally (Grayson 1993:11). The basin covers some 165,000 square miles, encompassing virtually all of the state of Nevada, much of eastern California, Western Utah, south-central Oregon, and small portions of southern Idaho and Wyoming (Grayson 1993:11).

The Great Basin is considered to be one of the classic locations where both ethnological and archaeological questions pertaining to forager societies can be broached (Aikens 1978:71). For archaeologists, the Great Basin presents a unique opportunity to study prehistoric forager subsistence and settlement patterns (Grayson and Cannon 1999:142). One reason for this is the lengthy occupational history of the region, which spans over 11,000 years (Grayson 1993:236). Just as important are the ecological conditions in which the regions inhabitants lived and the careful development of material culture appropriate for the environment (Aikens 1978:71). Grayson (1993:302) states, "[t]he correlation between human prehistory and environmental history in the Great Basin is striking…" (Grayson 1993:302). It is this sentiment that has lead to proliferation of evolutionary ecology in the Great Basin and development of the hypotheses that spurred this research.

Western Great Basin Ethnographic Context

The late nineteenth and early twentieth centuries are considered to be the dawn of American anthropology (Bettinger 1991:34-44; Stocking 1989:1). The modern path of American archaeology was laid out by Thomas Jefferson, who established many important precedents that would shape the future of American anthropology (Bettinger 1991:34). Most notably was the role of the Federal Government in development and support of anthropological research and the documentation of Native American life ways (Bettinger 1991:34). In the years to come Henry Lewis Morgan and John Wesley Powell continued Washington's role in American anthropology by commissioning anthropologists to construct ethnographies documenting the practices, beliefs, and traditions of Native American people across the United States (Bettinger 1991:36-37). The Great Basin, with its' arid and barren landscape remained the home to many Native Americans and was therefore the focus of much ethnographic documentation. These ethnographic accounts frequently contain information pertaining to Native American subsistence, settlement, technology, and hunting practices.

At European contact the Native American people now known as the Northern Paiute occupied the northwest Great Basin. Historically, these peoples called themselves "nomo," meaning "people," and they spoke a dialect of the Plateau Shoshonean language, known as the Numic language (Miller 1986:98; Stewart 1939:127). The regional ethnographies developed during the early twentieth century helped to further divide the Northern Paiute culture area into sub-areas, each of which was assigned to a particular band of Northern Paiute people. Figure 3 illustrates the territories of each of these Northern Paiute Bands.

During these formative years of Great Basin ethnography, the Northern Paiute allowed for neighboring bands to hunt and gather in areas beyond their traditional territory without risk of attract or reprisal. Underpinning this system of corporative land use among bands was a structure built on trade and intermarriage between groups (Steward and Wheeler-Voegelin 1974:3). There were of course exceptions, for example, Steward and Wheeler-Veogelin (1974:5-10) discuss the hostile interactions between the

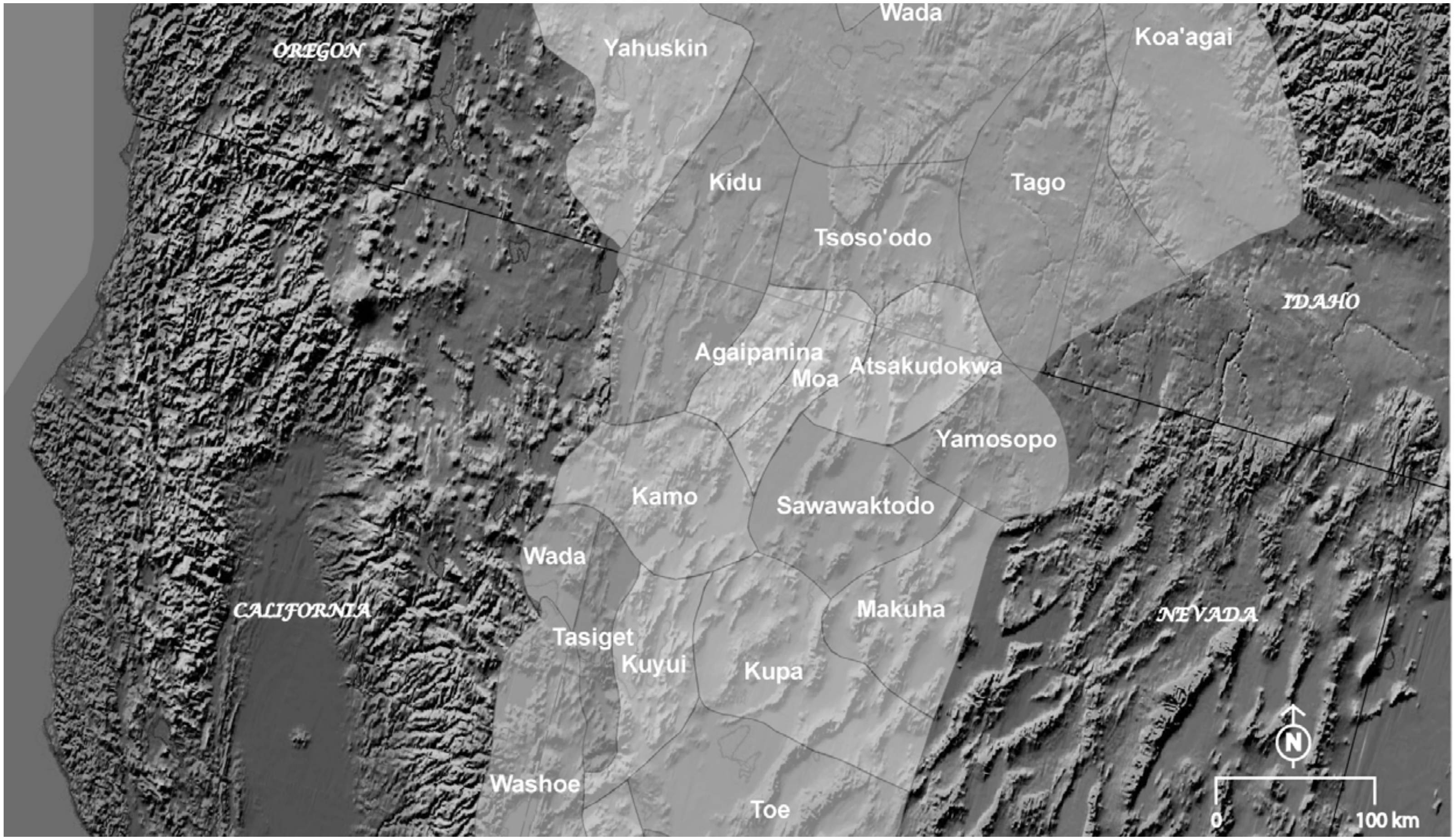

Figure 3. Northern Paiute ethnographic regions.

Source: Data set for map from Natural Earth, 2011, Free Vector and Raster Map Data. Electronic document, http://www.naturalearthdata.com/, Accessed February 2, 2011.

Honey Lake and Surprise Valley Paiute bands with the Maidu and Pit River Indians to the west.

Generally, the Northern Paiute lifestyle at the time of contact is characterized as one of seasonal movement centered on the availability of resources. From the spring through late fall, smaller family or task oriented groups people followed game herds or traveled to areas where seeds, nuts, berries or roots where plentiful. With the arrival of winter these smaller foraging groups came together to form temporary villages. The larger villages served as a platform for ceremonies and the development of inter-group relationships through marriage and trade (O'Connell 1975; Riddell 1960:40; Steward and Wheeler-Voegelin 1974; Stewart 1939).

While the documentation of activities related to hunting was not the main goal of Great Basin ethnography, there are occasional references to hunting activities, hunting party group size, and the use of stone hunting features. For the most part these references address the use of ephemeral sagebrush fences and corrals among Great Basin people in association with communal pronghorn hunts (Riddell 1960:40; Steward 1938:34).

Although the use of stone hunting features by Native Americans is not commonly noted in the ethnographic literature, these features are commonly observed and documented archaeologically. It has been suggested that this discrepancy may be related to changes over time in artiodactyl hunting strategies (Pendleton and Thomas 1983:34). Support for Pendleton and Thomas' change in hunting strategy hypothesis can be found in *Basin-Plateau Aboriginal Sociopolitical Groups* (Steward 1938). In this work, Steward argues that the "band" political structure observed among contemporary Native American people of the western Great Basin had not been in existence until contact with Euro-Americans (Steward 1938:245). Steward suggests that in the Great Basin these bands grew at the time of contact as a result of technological and economic changes, in addition to health and resource degradation (Steward 1938:246).

To support this argument, Steward (1938:251) describes events where numerous families would gather to complete a communal task (e.g., rabbit drive, pronghorn hunt, or festival). During these events individual leadership was ephemeral and task driven. According to Steward (1938:249) leadership and chiefly duties during these tasks had "…no precedence in the native institution."

After contact Native Americans in the western Great Basin underwent many changes including shifts in political organization and increased sedentation. Many Native Americans took up residence on farms as farm hands and with more efficient modes of transportation traditional local festivals were given up for larger festivals held within urban centers (Steward 1938:60, 236).

Basin-Plateau Aboriginal Sociopolitical Groups (Steward 1938) documented collective deer hunting strategies employed by the Owens Valley Paiute. The older tribesmen would station themselves at hunting blinds along game trails, while the younger tribesmen scouted the area for deer. Once located, the deer were driven past the hunting blinds, providing an opportunity for their capture (Steward 1938:36). The younger tribesmen are frequently referred to as chasers. These chasers usually numbered between three and five individuals; they used fire and possibly dogs to help flush the game past hidden archers (Steward 1938:60). The Owens Valley Paiute hunted pronghorn, deer, and sheep in the White Mountains. These animals were frequently shot near springs by archers canceled within stone blinds (Steward 1938:60).

Honey Lake and Surprise Valley and
Ethnographies

Riddell (1960) recounts the subsistence economy of the Honey Lake Paiute. He discusses the frequent movement of the group within their territory in pursuit of plant and animal recourses. Hunting of deer was frequent and they were taken whenever found with a seasonal preference towards fall and winter acquisition (Riddell 1960:39).

Pronghorn were hunted communally, usually in the spring (Riddell 1960:40). Families would produce rope and combine it together with rope created by other families. The long sections of rope were strung from heaps of sagebrush and stones that created linear fence-like features terminating in corral. When pronghorn approached the fence they would be herded in the direction of the corral (Riddell 1960:40).

Rabbit drives occurred frequently during the fall and winter and were also communal undertakings. These hunts used a system of nets supported by sticks; rabbits were then chased into the nets and then dispatched by a quick blow to the head (Riddell 1960:38). These communal events held important social significance for the participants. Rituals were held, marriages arranged, and goods exchanged (Riddell 1960:38).

When discussing animal acquisition strategies among the Surprise Valley Paiute, Kelly (1932:81) notes that deer and pronghorn were the primary target of native hunters. Deer were hunted throughout the year, usually to the north. Deer hunts occasionally took place at night (Kelly 1932:81). Surprise Valley Paiute hunting parties were generally comprised of groups of men, "…eight or ten [individuals] strong" (Kelly 1932:81). After locating a group of animals the hunting party would split into two teams, one team would flush the game while the other team would shoot from concealed locations as the game ran past (Kelly 1932:81). Deer were never hunted using nets or corrals (Kelly 1932:81). The animals were butchered where they fell (Kelly 1932:82).

According to Kelly (1932:83) pronghorn were hunted by groups of four or five individuals during the fall. A few individuals would flank approaching pronghorn herds and drive them towards the hunters who had concealed themselves and were ready to shoot any game that passed nearby. During winter hunts large herds of pronghorn were pushed into temporary corrals constructed of brush and dispatched in large numbers (Kelly 1932:83).

Ethnographic Summary

The Ethnographic documentation presented has provided evidence for forager task group formation, large game exploitation, and has suggested how stone features could have been used in association with hunting activities. It has shown that prehistoric foragers in the western Great Basin pursued high ranked prey items, such as deer and pronghorn, and likely traveled some distance to secure these resources, thus incurring the energetic cost associated with travel and the transport. The ethnographic literature has also indicated that Great Basin foragers assembled hunting parties that were commonly comprised of between four and ten individuals. The next section will build on the ethnographic documentation and strengthen the theoretical basis of this study by discussing archaeological data relating to the use of stone features in association with prehistoric hunting activities.

Northwest Great Basin Prehistory

Northeast California, formerly the western Great Basin, has been referred to "…California's best keep secret" and its "…least-known archaeological reserve" (Raven 1984:432). The prehistoric archaeology of the Great Basin is a rich mixture of caves and rock shelters, open-air village sites, lithic scatters, rock art, and stone features. Viewed in their entirety these phenomena create the archaeological landscape of the Great Basin. Much of what in known about the occupational history of the Great Basin has been achieved through the analysis of lithic technologies, the development of projectile point chronologies, and the use of obsidian hydration (Hughes 1986; Pendleton and Thomas 1983:4).

Over the last 35 years archaeological research in the region has resulted in a number of regional archaeological chronologies (e.g., Delacorte 1997; Hildebrandt and King 2002; Hildebrandt and Mikkelsen 1995, O'Connell 1975; Thomas 1981). These chronologies are generally so localized in nature that they cannot confidently address questions set forth in this study regarding central place foraging, travel and transports, and regional archaeological landscapes.

More recently, research has focused on synthesizing these early chronologies to eliminate confusion and allow for greater use (Delacorte 1997; Hildebrandt and King 2002; McGuire 2007). This section will introduce two chronological sequences developed for the research area, the Surprise Valley sequence (O'Connell 1975), and the Tuscarora sequence (Delacorte 1997), and prove a discussion of the prehistory of the western Great Basin. These chronologies are presented in Figure 4. Indicated within each temporal period are the projectile points types commonly associated with each period.

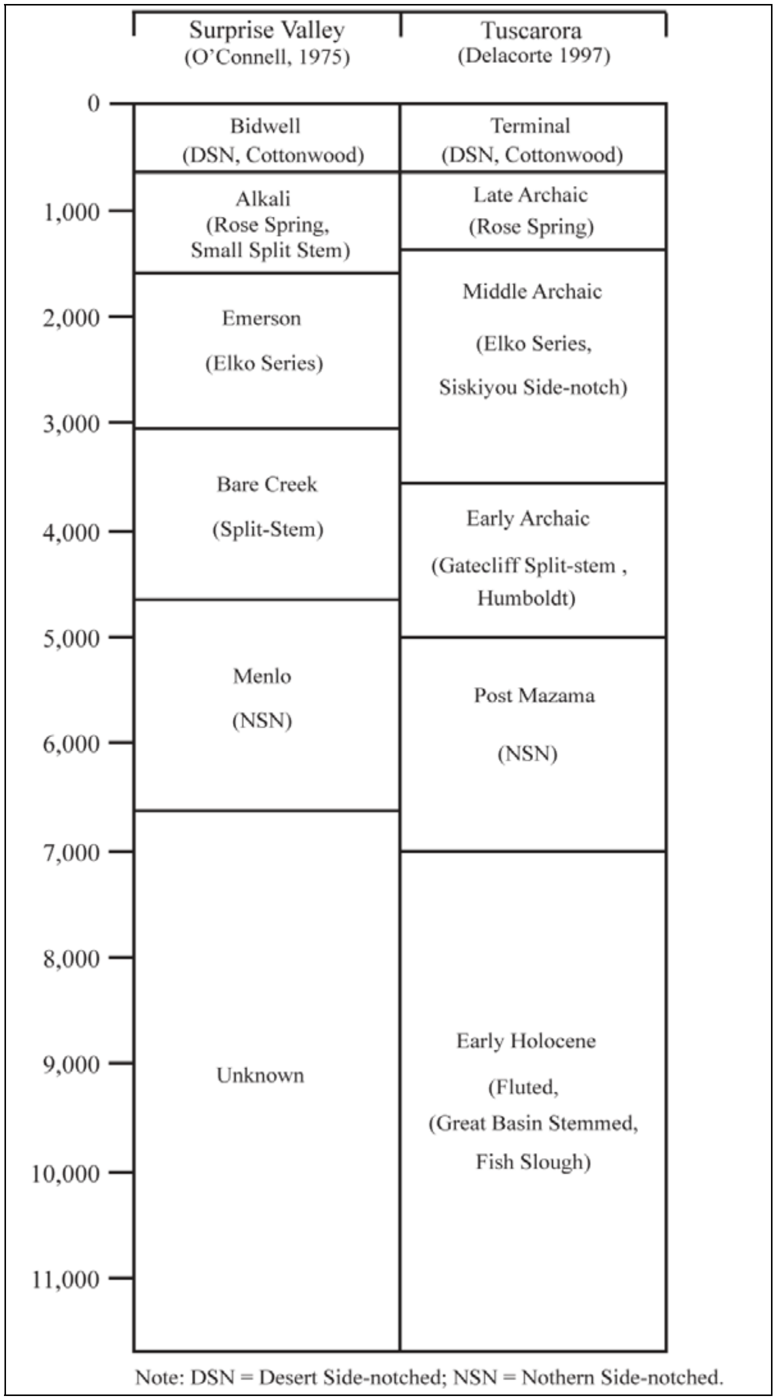

Figure 4. Regional chronological sequences and typical projectile point types for the study area.

Source: Adapted from Delacorte, M. G., 1997, *Culture Change Along the Eastern Sierra Nevada/Cascade Front.* Coyote Press, Salinas; O'Connell, J. F., 1975, *The Prehistory of Surprise Valley*. Ballena Press, Ramona.

The Surprise Valley sequence represents a localized chronology specific to the region in which this study occurs, whereas the Tuscarora sequence is a general chronology applicable to much of the northwest Great Basin. This study will utilize the Tuscarora sequence in the discussion and to address temporal shifts in technology and subsistence strategies.

The Tuscarora sequence, which parallels many other chronological sequences developed for the western Great Basin, was chosen over O'Connell's Surprise Valley sequence because of its regional applicability. A regional approach is more appropriate to this study because it can address questions related to regional hunting strategies, central place foraging theory, and the overall archaeological landscape of the western Great Basin to be broached; as these environments tend to encompass larger areas than are commonly represented in the more regional chronologies.

The validity of the Tuscarora sequence is confirmed by obsidian hydration values associated with each major time period (Delacorte 1997:66). In addition, the Tuscarora sequence is substantiated by 1556 projectile points and currently represents the most extensive source of chronometric information for the western Great Basin. The Tuscarora chronological sequence and its associated projectile point types will be used to provide relative temporal markers for the archaeological sites and associated stone hunting features in the northern Cowhead Basin.

The archaeological evidence for early human occupation in northeastern California comes in the form two styles of projectile points: leaf-shaped fluted projectiles, and stemmed points (Beck and Jones 1997:188-189). These projectile points are frequently assigned to either the Clovis or the Western Pluvial Lakes traditions

(Grayson 1993:236-244). Radiocarbon delivered from these projectile point styles date back at least 13,000 years. (McGuire 2007:165). These early Holocene assemblages frequently occur in lowlands and along the lakeshores of Great Basin's pluvial lake system (Beck and Jones 1997).

At the onset of the middle Holocene, about 8,500 B.P. the material culture of the northwest Great Basin becomes more diverse. Lithic assemblages begin to include various side and corner-notched dart point projectiles, bifaces, scarpers, and groundstone implements are used in seed processing and preparation. This occupationally period is generally referred to as the Archaic tradition (McGuire 2007:172).

The late Holocene dates to approximately 4,000 to 150 B.P. During this time human populations in the northwestern Great Basin appear to increase dramatically, resulting in a more intensive occupation of base camps, accompanied by the frequent use of logistical sites, such as hunting camps, and seed processing localities (Bettinger 1999; Kelly 1997; McGuire et al. 2004:15).

Archaeology of Surprise Valley

Surprise Valley is a long narrow valley, extending north-south for nearly 60 miles and east-west for between 10 and 15 miles (O'Connell 1975:15). The northern end of Surprise Valley lies about five miles southwest of Cowhead Basin. Within Surprise Valley is a chain of three Alkali Lakes; the lakeshores of which are dotted with prehistoric Native American village sites. In the late 1960s and early 1970s, O'Connell conducted a series archaeological investigations in Surprise Valley (O'Connell 1971, 1975; O'Connell and Ambro 1968; O'Connell and Ericson 1974; O'Connell and Hayward 1972). O'Connell surveyed much of the valley and excavated three major village sites: King’s Dog (CA-MOD-204) in the central valley, and Menlo Baths (CA-MOD- 197), and the Rodriguez site (CA-LAS-194) in the southern end of the valley.

O’Connell (1971, 1975) used data from these excavations to develop a chronological sequence for the Surprise Valley region. He observed the subsistence and settlement patterns were largely similar there was variation in the material culture and domestic structures over time (O’Connell 1975:23; Raven 1984:453).

The earliest occupation phase recognized by O’Connell, the Menlo phase (6,500-4,500 B.P.), is characterized by lowland villages with semi-subterranean dwellings, Northern Side-notch projectile points (O’Connell 1975:33). Faunal remains from this phase “… are dominated by ungulates [Artiodactyls], with jack rabbits, carnivores, and cottontails much less common” (O’Connell 1975:33).

The second phase in the chronological sequence, the Bare Creek phase (4,500-3,000 B.P.), is identified by the replacement of Northern Side-notch projectile points with the Bare Creek series, also referred to as Pinto or Little Lake points, and later termed Gatecliff, or Split-stemmed (Hughes 1986:204; O’Connell 1975:33). Also, during this phase brush wickiups replace the semi-subterranean dwellings, and the importance of large game in the diet appears to decline relative to small mammals and waterfowl. However, large game still appears to be remains an important component of the diet at the Menlo Baths site (O’Connell 1975:34-35).

The subsequent Emerson phase (3,000-1,500 B.P.) is characterized by appearance of Elko series projectile points (O’Connell 1975:34). Subsistence patterns remain similar to those from the Bare Creek phase, although O’Connell notes that faunal assemblage comparisons are impeded by a relatively small sample size (O'Connell 1975:34).

The Alkali phase (1,500-500 B.P.) is the last occupational phase developed from O'Connell's excavations. This period is characterized by the introduction of the Rose Spring projectile point series, also termed Rosegate (Hughes 1986:205; O'Connell 1975:34). Subsistence patterns during this period remain similar to those from the Bare Creek.

The final phase in O'Connell's occupational chronology of Surprise Valley is the Bidwell phase. The Bidwell phase extends from 500 B.P. to the historic contact period. The phase in defined by the appearance of Desert Side-notch projectile points (O'Connell 1975:35). While Desert Side-notches were not recovered in the context of excavation, they were found "…on the surface of sites in all areas of the valley…" (O'Connell 1975:35).

Tuscarora Archaeological Sequence

Drawing on data from investigations conducted along the routes of the Tuscarora Natural Gas Pipe, Delacote (1997) and Hildebrandt and King (2002) provide a clear and concise chorological framework for northeastern California and northwestern Nevada. The Tuscarora archaeological sequence incorporates data from a number of regional studies (e.g., O'Connell 1975), creating a single chronological sequence that is representative of the culture history for the entire region (Hildebrandt and King 2002:1).

The earliest occupational phase in the Tuscarora sequence is the Early Holocene period 11,000-7,000 B.P.). Foraging groups during this period were highly mobile, utilizing large foraging territories to travel to disperse but rich resource patches

(Beck and Jones 1997:221). Lithic assemblages consist of large bifacial cores, crescents, scrapers, and choppers (Delacorte 1997:70-73; Elston 1986). The period is marked numerous leaf-shaped, fluted, stemmed, and Fish Slough side-notch projectile points (Delacorte 1997:70-74; Hildebrandt and King 2002:11-12; King et al. 2004:24), and there is little evidence to support the use of groundstone (Elston 1986).

The subsequent Post-Mazama period (7,000-5,000 B.P.) is marked by the presence of ash from the eruption of Mount Mazama (Crater Lake, Oregon), which occurred around 7,000 B.P. Hunter-gatherer subsistence strategies during the Post-Mazama period employed frequent movement within large foraging territories, utilizing both upland game areas and wetlands (Beck and Jones 1997:181). Occupational locations tend to be found in association with permanent rivers and springs, suggestive of a shift in settlement from the previous period (Beck and Jones 1997:181). These shifts in adaptation maybe a response to the warm and dry conditions of the Middle Holocene (Elston 1986).

Archaeologically, the Post-Mazama period is defined by the presence of Northern Side-notched projectile points (Delacorte 1997:75-77). A smattering of various corner-notched, contracting stemmed, and dart projectile points are also found during this period (Hildebrandt and King 2002:11-12; King et al. 2004:24). The sparse nature of the archaeological assemblages may be a sign of relatively low human populations during this period (Beck and Jones 1997). Faunal remains from this period demonstrate a heavy reliance on fish, birds, and small mammals (Carpenter 2002:50).

The third phase in this chronological sequence, the Early Archaic period (5000-3000 B.P.), is characterized by Gatecliff Split-stem and Humboldt Concave Base projectile points (Delacorte 1997:77). Foraging territories remain large during this period (Smith 2010:800). However, archaeological assemblages from this period contain greater numbers of bifaces and flaked stone tools than observed during previous time periods. The archaeofaunal record from this period suggests a slight change in subsistence represented by exploitation of more medium sized mammals then in the preceding period (Carpenter 2002:50).

The Middle Archaic period (3,500-1,300 B.P.) is characterized by Elko series and Siskiyou Side-notch projectile points (Delacorte 1997:81). The Rose Spring projectile marks the first appearance of arrow points in the region. Arrow points are generally thought to have coincided with the technological switch from use of a spear and atlatl to the bow and arrow around 1,500-2,500 B.P (Elston 1986:145; Hildebrandt and King 2004:24; Webster 1980:64). Also, during this period archaeological deposits are continuing to diversify, suggestive of highly regularized settlement patterns. Faunal remains from this period show a strong reliance on smaller mammals and more costly resources (Carpenter 2002:50).

The Late Archaic period (1,300-600 B.P.) is dominated by Rose Spring projectile points, and is distinguished by the use of the bow and arrow technology (Delacorte 1997:86). This period is characterized by the centralization of settlements, reduced foraging territory sizes, and resource intensification (McGuire 2002:31; Smith 2010:800). The Late Archaic period also marks the onset of a major subsistence shift away from smaller animal resources to one focused on the exploitation of large game (Carpenter 2002:53).

The final phase in the Tuscarora sequence is the Terminal Prehistoric period (600 B.P. to European contact). This marks the arrival of Numic-speaking people to the region, and is characterized by Desert-side Notched and Cottonwood Triangular projectile points, with continued use of the bow and arrow (Delacorte 1997:88-89; Hildebrandt and King 2002:25). The larger settlements found during the Late Archaic become abandoned. During this period settlement appears to be characterized by family groups occupying independent camps during the summer and followed by settlement with other family groups in the winter to create large villages (Steward 1938:245).

Archaeological Summary

The northwest Great Basin is a productive venue to address questions pertaining to many aspects of the lives of prehistoric foragers. Modern archaeological research in the northwestern Great Basin is expansive, representing many of the major research themes important in hunter-gatherer studies across the globe. Research topics within this region include resource procurement, forager mobility, temporal transformation of foraging territories, and plant cultivation and processing (Bayham et al. 2011; Smith 2010; Trammell et al. 2008).

The archaeological evidence presented thus far suggests that the prehistoric inhabitants of the northwestern Great Basin practiced a highly mobile forager lifestyle centered on the seasonal availability of food resources. In addition, the composition of archaeological assemblages from the region suggests that hunting played an important role in the lives of Native Americans, of which large game hunting likely factored heavily.

Archaeology and Prehistoric Hunting in the Great Basin

Throughout the prehistoric Great Basin the principal large game hunting strategies appear to have been stalking, ambush, and driving game past a concealed hunter (Heizer and Baumhoff 1962:218). The archaeological remnants of these hunting activities manifest in the form of surface archaeological sites (Pendleton and Thomas 1983). Archaeological surface sites that are commonly associated with hunting activities include: cairns, blinds, corrals, fences, traps, and pits; all of which have possible association with hunting activities. These sites are frequently referred to as hunting enhancement features. Hunting enhancement features that are constructed from stone have higher survival rates than those comprised of organic material (e.g., sage brush), or those that may have been dug, creating subsurface concealment.

While the archaeological occurrence of hunting enhancement features has been frequently noted in the Great Basin, their analysis has been intermittent at best, lagging far behind lithic and stone art sites. This is most likely due to the "…lack in clear cut associations, making them [hunting features] difficult to analyze" (Pendleton and Thomas 1983:4).

The Fort Sage Drift Fence has become fundamental to our understanding of the complex nature of stone hunting features in the Great Basin. The Fort Sage Drift Fence consists of five linear stone features, ranging from twenty to eighty centimeters in height and span a distance of almost one thousand meters (Pendleton and Thomas 1983:7). The costs associated with the construction of such features are undoubtedly high. However, its permanence allowed for annual return during periods of large game migration through the region (Pendleton and Thomas 1983).

Brook (1980) undertook a study in Inyo County California. Within this study he made two key observations. First, he noted that although stone hunting blinds tend to be more clustered at water sources they could be found throughout the study area. Second, he observed a correlation between a blinds distance from a water source and its distance from a game trail leading to that water source (Brook 1980:62-64). He showed that as the distance from the watering hole increases so does the blind’s placement in relation to the game trail. Brook suggests these outlying features may have served as additional ambush locations, or as singling stations during collective hunts (Brook 1980:64).

At the Mt. Augusta site in central Nevada stone features were observed to have a consistent spacing of 10 to 15 meters. These features clustered to form a larger northwest-southeast trending feature (McGuire and Hatoff 1991:97). In test excavations of the features McGuire and Hatoff note post-hole-like depressions in several of the cobble features. They suggest that these cobble features may have served as anchor points for wooden post “dummy hunters,” or they may have supported a larger system of nets (McGuire and Hatoff 1991:107).

The archaeological association of stone features with hunting activities is widespread in the Great Basin. The above archaeological literature review not only illustrates this aspect of the archaeological record, it also demonstrates that these features are often expansive, with components logistically placed in relation to each other and the natural landscape. The construction of these stone hunting features represents a considerable energetic investment of the part of prehistoric hunters, suggesting that the evolutionary returns achieved from high ranked prey, such as mule deer were sizeable. The use-life of stone features is also much longer than that of features comprised of organic materials. Thus, foragers traveling from a central place to a distant hunting location could likely use previously constructed features over a period of several years with little modification, successfully lowering the energetic costs associated with prey purist time. Subsequently, this decrease in energetic investment would increase the targets prey item's rank within the resource patch, alleviating some of the costs associated with travel and transport.

Decreased energetic investment at hunting locations likely created additional free time to engage in ceremonial practice and create art. Much research has been done concerning the role ceremony and art in the form of petroglyphs played in prehistoric hunting practices. Petroglyphs frequent the archaeological record of the western Great Basin, and the next section will discuss some of the interpretations of these features and their possible association with large game hunting.

Artiodactyls and the Environment

The density of artiodactyls on the landscape has varied through time (Beck and Jones 1997; Broughton and Bayham 2003; Broughton et. al 2008; Byers and Broughton 2004; Grayson 1993). The fluctuation of these populations undoubtedly influenced forager hunting strategies and decisions regarding prey selection. When artiodactyls populations were high it is likely they were more frequently encountered and captured by foragers, subsequently comprising a larger portion of the diet compared to times when their populations low. This section will discuss the terminal Pleistocene and the Holocene environments and their influence on artiodactyl populations in the Great Basin.

Broughton and colleagues (2008) show that seasonal variation in temperature and precipitation significantly affects artiodactyl populations. The nature history of Artiodactyls (i.e., survival, birth rate, and overall health) is closely linked to the duration of growing season, and the quality of forage produced during the spring and summer months (Broughton et al. 2008:1917). Artiodactyls experience the greatest energetic returns from the consumption of new plant growth, which is typically most abundant after periods of rain followed by sun. Consequently, wet and warm periods of time, with high amounts of summer rain fall and little seasonal variation make excellent conditions for the expansion of artiodactyl populations (Broughton 2008:1917).

Overall, the terminal Pleistocene (12,000 B.P.-10,000 B.P.) and the early Holocene (10,000 B.P.-7,500 B.P.) appear to have been cool and wet, with high plant productivity. However, these periods are marked by high levels of seasonality, consisting of hot and dry summers followed by cold, wet winters (Broughton 2008:1930). These conditions likely kept artiodactyl population low.

The winter-wet pattern continued into the middle Holocene (7,500-5,000 B.P.). This period experienced considerably less annual rainfall and is generally characterized by low plant productivity. Artiodactyl numbers remained low though much of the middle Holocene (Broughton 2008:1930). However, O'Connell (1975) indicates that natural springs within Surprise Valley, in the northwestern Great Basin flowed through the middle Holocene, likely keeping artiodactyls population relatively high in the region. Byers and Broughton (2004:249) note that taphonomic issues prevent a secure conclusion for artiodactyls populations in the Surprise Valley area. Although, they do note that the portion of artiodactyl remains in the faunal record is generally higher in the Surprise Valley region when compared other Great Basin locations.

The late Holocene (5,000 B.P.-latest prehistoric) is thought to have had the most equable climate during the Holocene. The period is marked by a shift from a winter-wet climate to more of a summer-wet climate (Broughton 2008:1930). The increase in summer forage resulting from ample summer rainfall boosted artiodactyl populations during this period. Expanding artiodactyl populations during the late Holocene had a dramatic affect on human populations in the region (Kelly 1997:11). This increase of artiodactyls on the landscape likely drove the establishment of new technologies and hunting strategies, including the use of hunting blinds and the bow and arrow.

Hunting Behavior and Petroglyphs

One of the most common arguments in contemporary Great Basin archaeology is that petroglyphs are associated with big game hunting (Hildebrandt and McGuire 2002). Hiezer and Baumhoff (1962) tested this hypothesis in a synthesis of the petroglyphs of Nevada and Eastern California. They found that hunting blinds are commonly associated with a variety of petroglyph styles and that the placement of petroglyphs can aid in the interpretation of prehistoric hunting practices (Hiezer and Baumhoff 1962:221-225).

Petroglyphs in the southern Great Basin tend to be placed near to watering holes were animals approaching for a drink could be ambushed (Hiezer and Baumhoff 1962:223). Whereas, petroglyphs in the northern Great Basin are frequently located on apparent or documented game trails, usually within drainages (Hiezer and Baumhoff

1962:224). Hiezer and Baumhoff (1962:224-225) suggest the relatively wet climate in the northern Great Basin compared to the southern region necessitated a different hunting approach. Animal behavior would be different in each region, with game concentrated around specific watering holes in the southern Great Basin, while in the north game would have more opportunity for water while moving across the landscape. The placement of petroglyphs in the north suggests that instead of hunting game as it came to watering holes to drink, northern hunters ambushed or trapped game traveling from one section of their range to another or during their annual migration (Hiezer and Baumhoff 1962:224).

Hiezer and Baumhoff's (1962) study illustrates the importance petroglyphs to the archaeological record of the western Great Basin. The recurrent association of petroglyphs with localities frequented by high rank prey items suggests that these features are an indication of hunting behavior.

Performance Characteristics of the Bow and Arrow

The hypothesis posed in this study suggested that hunting blinds would be spaced according to the performance characteristics of Native American hunting technologies. As discussed above, the patterns in animal behavior make water sources an optimal location for the placement of hunting blinds. If particular hunting blinds proved productive for capturing game, it is likely that foragers would continue to using these blinds with little to no modification over time. In other words, a productive hunting blind could by used continually for thousands of years. The archaeological record is essentially represents the last time a site, artifact or feature was used. This study assumes that once constructed a hunting blind would remain in use until it is removed from the landscape. Therefore, it also assumes that hunting blinds were used in conjunction with the bow and arrow hunting technology.

Fundamentally, "…a bow is two armed spring spanned by a string" (Hamilton 1982:1), and an arrow is its projectile. In the prehistoric Great Basin both items would have been constructed of wood, with the arrow tip likely made for a lithic material (e.g., obsidian, basalt, or chert). When an arrow is placed in the bow and the string drawn back the bow stores potential energy. Upon the release of the string the stored energy is discharged and the arrow is thrown into flight (Bergman et al. 1988:659). Together the design bow and arrow take advantage of the natural properties of the materials used in it construction to create a very energy-efficient weapon (Bergman et al. 1988:658).

Saxton Pope's (1918, 1923) publications stemming for his work and friendship with Ishi, a Yana Indian from northeastern California, likely represents the most thorough ethnographic studies conducted on Native American archery and hunting in North American. The traditional territory of the Yana is situated on the western slope of the northern Sierra Nevada mountain range in what is now Tehama County. This region lies outside boundaries of the Great Basin, however, it is likely that the Yana had substantial contact with their Great Basin neighbors to the north and east is north (Garth 1978:238), and it is possible that ideas and technologies were passed among groups. Thus, Pope's works concerning the Ishi's capabilities with the bow and arrow represents an appropriate analogy for Great Basin hunters, the performance characteristics of their bow and arrow technology, and subsequently for the questions posed in this study.

According to Pope (1918:123) a traditional round in American archery consists of shooting 30 arrows from each of the following distances: 55, 46, and 37 meters. The target used for this activity is a circular straw mat four feet in diameter covered by five concentric rings. The center ring or bulls-eye has a diameter of nine and one-half inches and each of outer rings grow consecutively by one-half inch diameter (Pope 1918:123,124).

In 1914 and 1915, Ishi participated in two rounds of American style archery (60 arrows from each distance). Table 1 provides a summary of Ishi's American Archery round results. Ishi hit the target a total of 23 times from 55 meters, 37 times from 46 meters, including two bulls-eyes, and 42 times from 37meters, including three bulls-eyes. As impressive as these scores are, Pope (1918:124) notes that Ishi was considerably more accurate at distances ranging from 9 to 18 meters and that he preferred to shoot at targets in motion or through a thrown hoop.

Table 1. Summary of Ishi's American Archery Round Results in 1914 and 1915.

Distance (m)	Hits 1914	Bulls-eyes 1914	Hits 1915	Bulls-eyes 1915	Hits per distance
55	10	0	13	0	23
46	18	2	17	0	37
37	17	2	22	1	42
Hits bulls-eyes per year (60)	45	4	52	1	102

Ishi also indicated to Pope that that the Yana hunted deer by way of ambush, stationing hunters behind rock or bushes alongside known game trails. During a trip into

Yana territory Ishi showed Pope game trails where small rock features large enough to conceal a hunter had been placed along the trails (Pope 1918:127).

The information provided by Pope (1918) can certainly be generalized to address questions pertaining to the accuracy of prehistoric hunters utilizing bow and arrow technology in western North America. These data suggest that the optimal position of individual hunters when shooting from a stationary location at a moving prey item would be no further then 18 meters.

Hunting Technology and Hunting Blinds

Through the use of the available ethnographic and archaeological documentation this chapter has shown that there is a relationship among archaeological hunting blinds and large game hunting in the prehistoric Great Basin. The creation and maintenance of these hunting blinds represents an economic investment by Native Americans. As a result, these blinds likely remained in use for longs periods, extending well into Late Archaic and Terminal Prehistoric times. This study assumes that the hunting blinds used in this research were used in association with the bow and arrow.

Utilizing Pope's (1918:124) observation that Ishi, a single Native American hunter, was most comfortable shooting moving objects at a maximum distance of 18 meters and doubling it to 36 meters, a distance reflective of numerous hunters shooting from opposite directions toward each other, the argument can be made that 36 meters represents the optimal spacing for hunting blinds under the auspication of collective hunting. This research contends that prehistoric hunting blinds will be spaced in accordance with the optimal performance of the bow and arrow, and therefore these features should be spaced on average a distance of 36 meters apart.

There are a number of variables that can influence the spacing of hunting blinds. As discussed earlier in this chapter, large game hunting may have frequently taken place at night. Generally, hunter visibility would have been not as good during night hunts as it would have been during the day. This practice may cause the distance between hunting blinds to be less than that expected from the optimal performance of the bow and arrow. Also, the topography of a region may drive the placement of hunting blinds, which would result in varying distances among features. This research accepts that these two variables may have influenced the construction of prehistoric hunting landscape, however for the purpose of this study, it assumes that they did not.

Chapter Summary

A lot has been accomplished in this chapter. It has presented regional and local ethnographic documentation of Native American hunting practices. The data contained within these ethnographies has shown that Native Americans utilized stone hunting blinds and frequently foraged in groups when pursuing large game. This chapter has drawn archaeological support from numerous Great Basin case studies for the association of hunting blinds and petroglyphs with large game hunting. In addition, it has provided a discussion regarding the performance characteristics of the bow and arrow. The data presented in this chapter has allowed for an expectation pertaining to the optimal spacing of prehistoric hunting blinds to be developed; this expectation states that on average hunting blinds will be spaced 36 meters. This distance represents the optimal capture range of the bow and arrow when employing a collective hunting strategy.

The examples of ongoing archaeological research in the northwestern Great Basin provided in this chapter have demonstrated that the research in the region is in the vanguard of evolutionary ecology, and they have provided the context under which this research will occur. The area selected to carryout the field component of this research is Cowhead Slough. Situated in northeastern California only meters away from the Oregon and Nevada state boarders, Cowhead Slough typifies the environment of the western Great Basin. The next chapter will outline Cowhead Slough in detail.

CHAPTER IV

COWHEAD SLOUGH AND FIELD METHODOLOGY

Preceding chapters have introduced the theoretical perspective of evolutionary ecology and discussed the suitability of the Great Basin to archaeological applications of this theoretical approach. They have provided the archaeological context in which this research will occur, and outlined research expectations. This chapter will first provide an introduction to the natural environment of the Cowhead Basin. This section will demonstrate that the Cowhead ecosystem offers a number of potential prey items for prehistoric foragers. It will also illustrate the importance of the region to high ranked prey items (e.g., artiodactyls) and subsequently to the Native Americans who hunted them.

Then I will identify and discuss previously completed archaeological studies and documented archaeological sites within the northern Cowhead Basin. The purpose of this section is to illustrate how the archaeological record of the basin supports the notion of the region as a hunting destination for prehistoric foragers. Finally, this chapter will present an explanation of the archaeological fieldwork undertaken as part of this study and the data collection methodology used in the Cowhead Slough archaeological survey, which forms the backbone of this research.

Cowhead Basin Environmental Context

The Cowhead Basin is situated at the northwestern edge of the Great Basin, roughly 25 miles north of the town of Cedarville, California (Figure 5). The basin comprises over 5,600 acres and is completely within California state boundaries, although only meters from both the Nevada and Oregon state lines. Considered part of the North Lahontan Hydrologic Region; water from Cowhead Basin drains interiorly into the western United States (Grayson 1993).

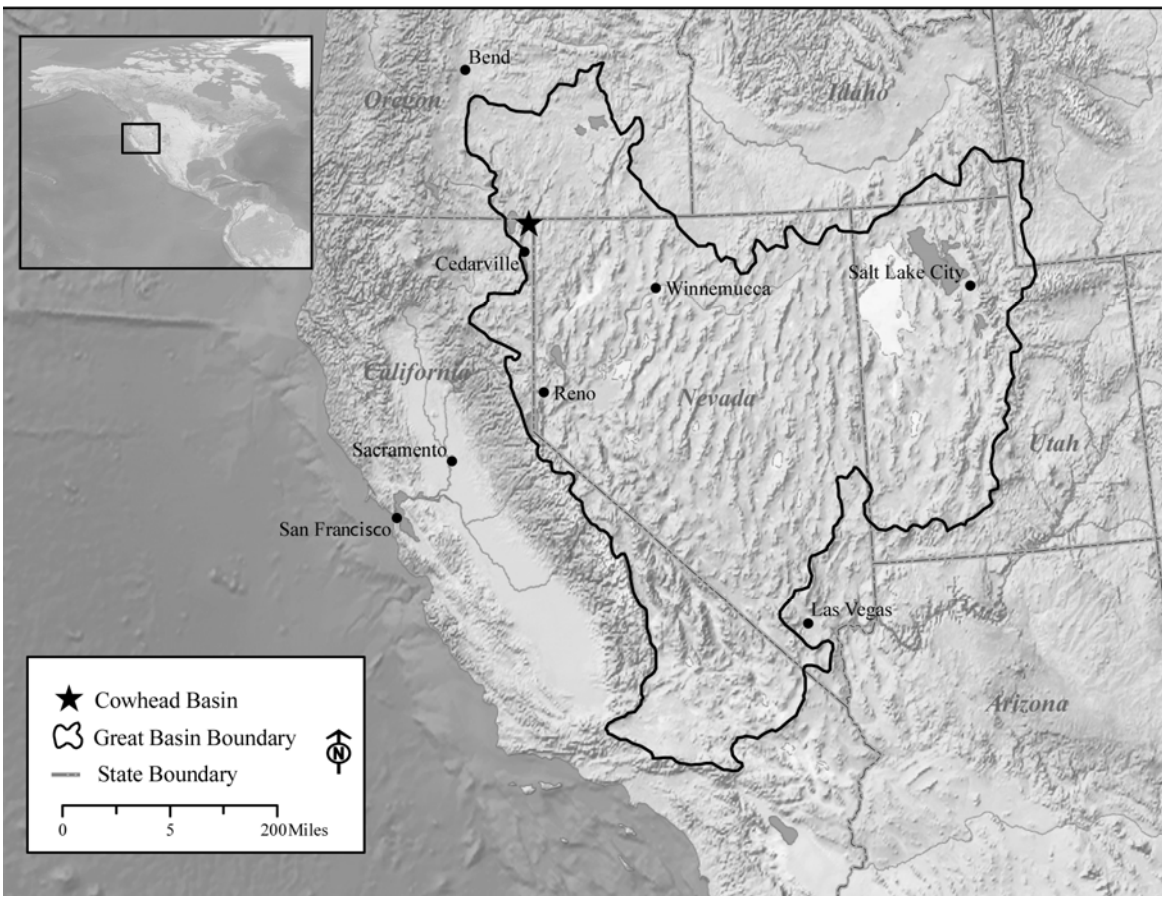

Figure 5. Topographic map indicating the location of Cowhead Basin.

Source: Data set for map from Natural Earth, 2011, Free Vector and Raster Map Data. Electronic document, http://www.naturalearthdata.com/, Accessed February 2, 2011.

Bound to the west by the Warner Mountains, the Cowhead Basin is defined by two major hydrologic features, Cowhead Lake and Cowhead Slough (Figure 6). Cowhead Lake (2,700 acres) receives most of its water from the snowmelt run-off of the Warner Mountains in the spring (Sato 1992:7). Water from the lake drains to the north via Cowhead Slough, a small, muddy creek that meanders through a lava canyon. The Slough is approximately 50-125 meters wide that consists of a series of pools and some riffles during the spring and early summer (Sato 1992:9). Cowhead Slough drains into Twelve Mile Creek, which flows into Twenty Mile Creek, eventually feeding into the Warner Valley of eastern Oregon.

Cowhead Basin is an ecotonal environment. An ecotone is a location where two or more local plant communities merge together. Ecotones are usually narrow strips of land that as a result of environmental blending often have a greater variety of species, at higher densities than are found in either independent community. This phenomenon is known as the edge effect (Agarwal 2008:227).

An introduction to the vegetal and animal communities present in the Cowhead Basin is an essential to this study for two reasons. First, by providing a detailed description of the plant and animal communities I will establish that both food for prehistoric foragers, and fodder, cover, and habitats generally preferred by a variety of animal species representing potential prey items are present with the basin. Second, the description of animals present in the Cowhead Basin will show that foragers utilizing the basin had the opportunity to pursue a variety of prey items.

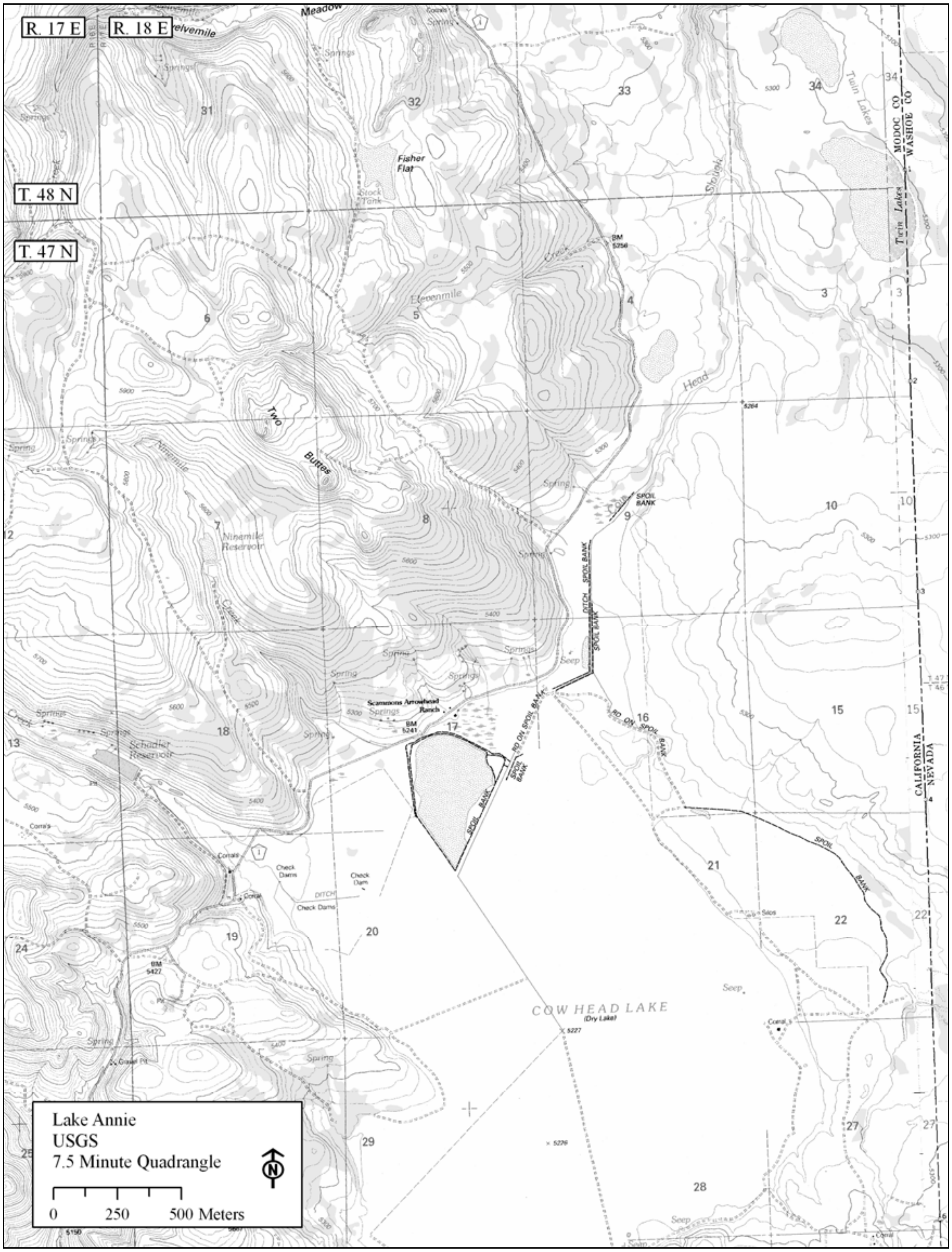

Figure 6. USGS Lake Annie topographical map depicting the northern Cowhead Basin.

Source: Adapted from United States Geological Survey, 1990, Lake Annie Quadrangle, California 7.5 Minute Series Provisional Edition, Reston, VA: United States Geological Survey.

Vegetation Communities in the Cowhead Basin

Vegetation in the basin itself includes shrubs, herbaceous plants, and grasses assigned to the sagebrush steppe community (Trimble 1989:93). Among the trees and shrubs are big sagebrush (*Artemisia tridentate*), rabbitbrush (*Chrysothamnus viscidiflorus*), mountain-mahogany (*Cercocarpus spp.*), shadescale (*Atriplex confertifolia*), greasewood (*Sarcobatus baileyi*), Western juniper (*Juniperus occidentalis*), and an occasional yellow pine (*Ponderosa spp.*). Various grasses exist in the basin, including bluebunch wheatgrass (*Pseudoroegneria spicata*), bottlebrush squirreltail (*Elymus elymoides*), Indian ricegrass (*Oryzopis hymenoides*), Sandberg bluegrass (*Poa sandbergii*), Thurber needlegrass (*Achnatherium thurberianom*), and the exotic cheat grass (*Bromus tectorum*) (Trimble 1989: 93-110; Young et al. 1988:771-784).

The Warner Mountains are dominated by a white fir (*Abies concolor*), ponderosa pine (*Ponderosa ponderosa*), Jeffery pine (*P. jeffreyi*), Washoe pine (*P. washoensis*) overstory. Manzanita (*Arctostaphylos sp.*), buckbrush (*Ceanothus cuneatus*), and bitterbrush (*Purshia tridentata*) create the majority on the understory. A number of wild fruits and berries are common in the Warner Mountains including chokecherries (*Prunus virginiana*), wild currant (*Ribes cereum*), Black Haw (*Crataegus douglasii*), Buffalo berry (*Shepherdia argentea*), and serviceberry (*Amelanchier venulosa*) (Young et al. 1988).

<u>Animal Communities in the Cowhead Basin</u>

Animal populations in the Great Basin are closely tied to plant communities, water availability, and other environmental conditions (Grayson 1993:196, 219). The Cowhead region is home to numerous species of birds, fish, and mammals. Rodents in study area include marmots (*Marmota flaviventris*), porcupines (*Erethizon dorsatum*), woodrats (*Neotoma sp.*), ground squirrels (*Spermophilus* and *Ammospermophilus sp.*), chipmunks (*Tamias sp.*), kangaroo rats (*Dipodomys sp.*), pocket mice (*Perognathus sp.*), deer mice (*Peromyscus sp.*), and voles (*Microtus sp.*) (Hall 1946; Zeveloff 1988).

Carnivores of note include black bear (*Ursus americanus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), puma (*Puma concolor*), bobcat (*Felis rufus*), American badger (*Taxidea taxus*), long-tailed weasel (*Mustela frenata*), striped skunks (*Mephitis mephitis*), and spotted skunks (*Spilogale gracilis*). There are also a number of artiodactyls inhabiting the Cowhead region including mule deer (*Odocoileus hemionus*), and pronghorn (*Antilopcapra americana*). Historically, Elk (*Cervus canadensis*) and Mountain sheep (*Ovis canadensis*) were available in the upland areas of the Warner Mountains (Hall 1952).

The seasonal occupation of geographic regions by migratory artiodactyls, mainly mule deer and pronghorn are necessary to ensure that the nutritional needs of these animals are achieved (Sawyer et al. 2005:1266). The geographic location and ecotonal environment of Cowhead Basin make it a likely area to find these animals. In fact, a handful of studies (Fish and Game; Skiff et al. 1991) have identified Cowhead Basin as a migration destination and kidding ground for pronghorn (Figure 7), and wintering and kidding ground for mule deer (Figure 8).

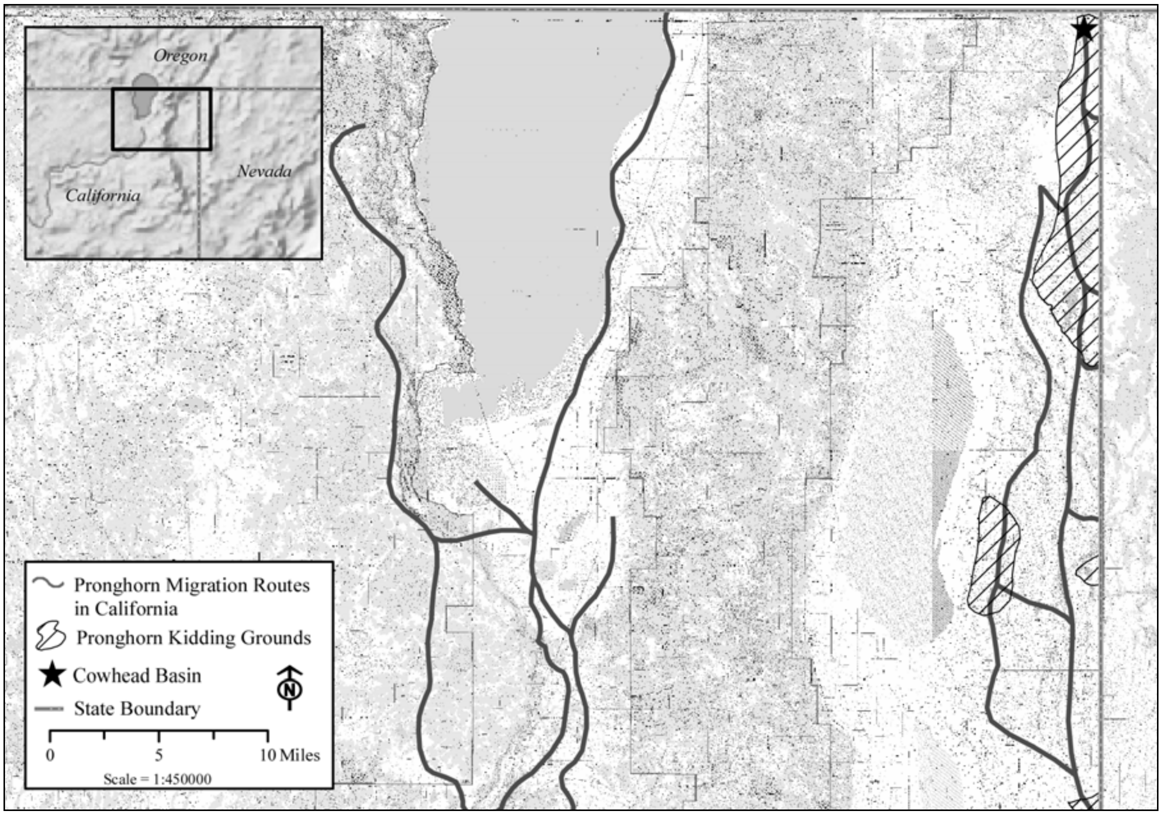

Figure 7. USGS topographic map illustrating pronghorn migration routes and kidding grounds in northeastern California.

Source: Adapted from United States Geological Survey, 2001, *Vya, Nevada*, 1:100,000 scale topographic map, 30x60 minute series, Denver, CO: United States Geological Survey; 2002, *Cedarville, California*, 1:100,000 scale topographic map, 30x60 minute series, Denver, CO: United States Geological Survey.

Dispersal is essential to the adaptive success and survival of these artiodactyls; it provides a buffer from inbreeding and provides new habitat, while relieving pressure from overpopulation and localized hunting activities (Robinette 1966:346). During both the summer and winter pronghorn and deer disperse into areas referred to as home ranges.

During periods of migration to and from home ranges deer and pronghorn use transitional ranges. These transitional locations are used for as long as possible before the animals are forced to move on due to snow (Robinette 1966:336). In general, mule deer

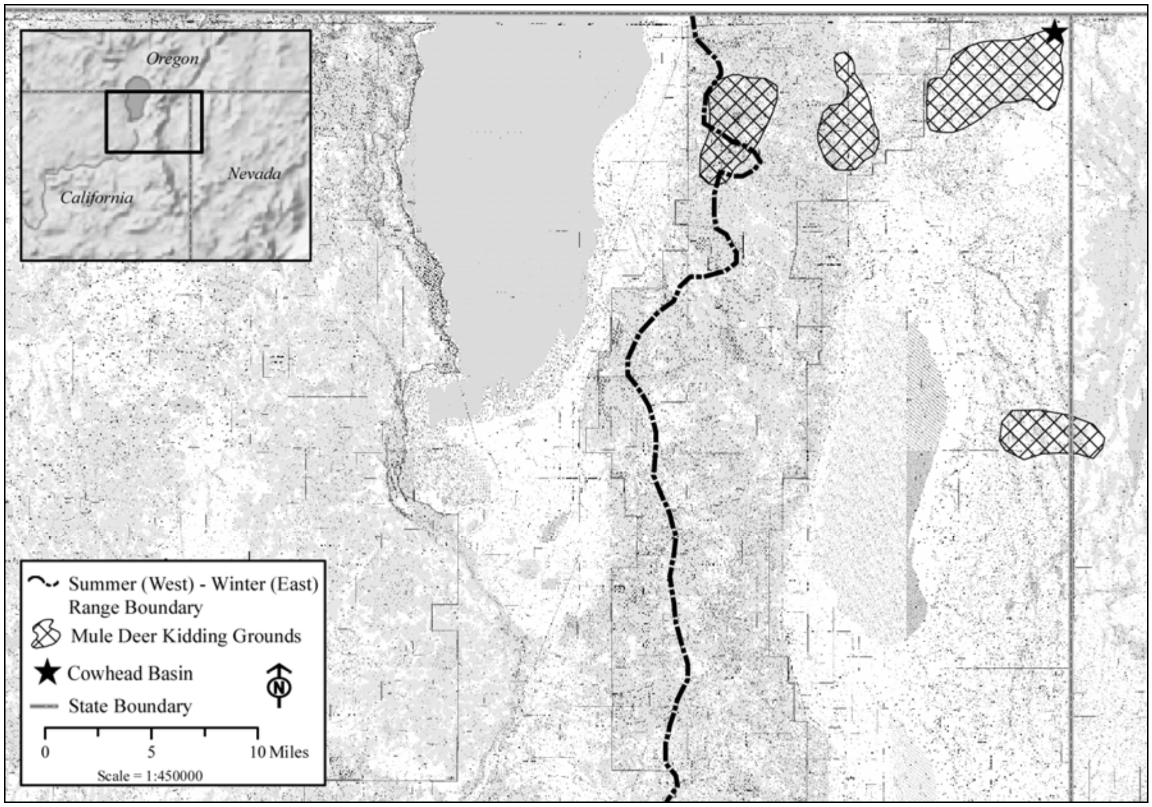

Figure 8. USGS topographic map illustrating mule deer summer and winter range and kidding grounds in northeastern California.

Source: Adapted from United States Geological Survey, 2001, *Vya, Nevada,* 1:100,000 scale topographic map, 30x60 minute series, Denver, CO: United States Geological Survey; 2002, *Cedarville, California,* 1:100,000 scale topographic map, 30x60 minute series, Denver, CO: United States Geological Survey.

tend migrate shorter distances compared to pronghorn, utilizing the transitional locations for much longer. Pronghorn migrate long distances and move as quickly as possible to avoid snowy conditions, whereas the movements of mule deer are not as inhibited by snow (Sawyer et al. 2005). Sawyer and colleagues study takes place in the Green River Basin of western Wyoming, an area characterized by sagebrush, greasewood, and various grasses. Western Wyoming in general has a large and varied population of ungulates; during the winter months the Green River Basin carries in the neighborhood of 32,000 mule deer and 48,000 pronghorn (Sawyer et al. 2005:1267).

Data for this research is derived from 171 radiomarked adult mule deer (12 male and 159 female). Within the mule deer sample 27 individuals were provided with global positioning system collars, and 144 given VHF collars. In regards to the pronghorn, 35 individuals (34 female and one juvenile) were radiomarked, however two died from capture related injuries leaving the pronghorn sample at 33 individuals (Sawyer et al. 2005:1268).

The mule deer were marked on winter ranges located in the northern GRB, and the pronghorn on summer ranges in Grand Teton Park, and Gros Ventre River Drainage. Mule deer movements were monitored from February 1998 to April 2001. During that period over 36,000 locations were recorded. Pronghorn were monitored from August 1998 and June 2008, and were located 981 times (Sawyer et al. 2005:1269).

In regards to mule deer, 158 individuals were migratory. Spring migration, from winter range to summer range, began in early April and concluded in June. Autumn migrations commenced in October/November and ended in December. On average mule deer migrations where accomplished over a period of 60-90 days, covering a distance of 3.3 km (Sawyer et al. 2005:1270).

All of the pronghorn monitored as part of Sawyer and colleagues study were migratory. Autumn migrations took place between October and December and averaged 19 days, with some completed in seven. In contrast, the spring pronghorn migrations occurring between March and June took significantly longer to complete, averaging 73 days. The migratory distances traveled by pronghorn were between 116-258 km (Sawyer et al. 2005:1269).

In summary, mule deer within this study tended to use transitional range locations longer than pronghorn, and their movement were not as inhibited by snow. The pronghorn migrated long distances, and during their autumn migrations moved as quickly as possible avoiding snowy conditions. This article demonstrates importance of not only summer and winter ranges, but also transitional areas along the migration corridors.

The use of summer, winter, and transitional ranges along migration corridors factor prominently into the lifecycles of deer and pronghorn, and it appears that the Cowhead Basin played an important role in this annual cycle for local artiodactyls. The presence of large game was likely a major factor influencing the Native American use of the Cowhead region. The ecotonal qualities found within the Cowhead region may have allowed Native American foragers to pursue these two favored species of large mammals in a single hunting location.

Previous Archaeological Research in the Cowhead Basin

Chapter III reviewed the considerable amount of archaeological research that has been conducted in the western Great Basin. This previous research has shown that region is exceptionally rich in archaeological resources and is subject to a long well-defined culture history sequence. However, archaeological research in the Cowhead Basin itself has been limited to a few small project driven surveys. This section will review the archaeological research that has been conducted in the Cowhead Basin. The goal of this section is to demonstrate that the archaeological material within Cowhead Basin is almost completely comprised of hunting related material (e.g., projectile points, lithic scatters, petroglyphs, and rock features).

Literature reviews conducted at the Surprise BLM office and at the Northeast Information Center at California State University Chico revealed that four archaeological surveys have been previously conducted in the northern Cowhead Basin. These literature reviews were restricted to the northern Cowhead Basin because Cowhead Slough is the focal point of this study, and Cowhead Lake encompasses well over four square miles, creating a large natural buffer from sites to south.

The earliest systematic archaeological investigation in the northern Cowhead Basin was an archaeological survey conducted by BLM archaeologist Christopher Corson in 1977. Corson's survey consisted 100 meter spaced pedestrian transects on a north-south direction parallel to Cowhead Slough for a distance of two miles, covering approximately 287 acres. Corson documented 14 prehistoric archaeological sites (Corson 1977:1).

In 1993, BLM archaeologist Hugh Bunten carried out an archaeological reconnaissance for the Surprise Valley Electric Project along Modoc County Road 1 just to the west of Cowhead Slough. Bunten documented no archaeological resources (Bunten 1993:1).

During the field season of 2000, BLM Archaeologist Penni Borghi performed a pedestrian survey at Elevenmile Spring. Elevenmile Spring lies about 800 meters to the west of Cowhead Slough; the spring feeds Elevenmile creek, which drains into the Cowhead Slough. Borghi documented one prehistoric archaeological resource (Borghi 2000:1).

The most extensive archaeological survey completed in the northern Cowhead Basin was conducted by Far Western Anthropological Research Group in 2006

(Carpenter 2006). This survey was of 305 acres of private property along the northwest banks of Cowhead Lake and southern portions of Cowhead Slough for the purpose of acquiring a United States Department of Agriculture (USDA) Environmental Quality Incentive Programs (EQIP) grant to assist the landowner with juniper removal to promote the health and regrowth of a sagebrush steppe ecosystem (Carpenter 2006:1). The Far Western survey documented 22 archaeological sites. Nineteen of the archaeological sites contained only prehistoric debris, two contained minimal historic refuse, and two were prehistoric with substantial historic deposits (Carpenter 2006:24).

A total of 50 archaeological sites have been previously identified through project related activities in the northern Cowhead Basin. Table 2 provides an account of each previously recorded archaeological site. The site number is given in column one. Column two indicates weather the resource is prehistoric or historic in origin. A brief description of each site is given in column three. Column four indicates temporally diagnostic projectile points documented at the site, and column five provides the corresponding Tuscarora temporal period assigned to the each diagnostic artifact.

Of the 50 previously recorded archaeological sites, 48 are associated with a lithic scatter, one contains only petroglyphs, and one consists of a petroglyph and a rock feature. There are a total of five petroglyph sites, three of which contain both petroglyphs and rock features. Four of the previously recorded sites contain either rock features or hunting blinds.

In regards to the temporal affiliation, there are 16 archaeological sites that contain diagnostic projectile points. Of these 16 sites, 12 appear to be temporally associated with the Middle and Late Archaic periods, one site contains a great basin

Table 2. Previously recorded archaeological sites in the northern Cowhead Basin.

Site Number	Type	Description	Temporal Markers	Tuscarora Sequence Temporal Association
47.17.03.01	Prehistoric	Light density lithic scatter	None	None
47.17.03.03	Prehistoric	Diffuse lithic scatter	Rose Spring	Late Archaic
47.17.03.04	Prehistoric	Light density lithic scatter	None	None
47.17.03.05	Prehistoric	Light density lithic scatter	None	None
47.17.04.01	Prehistoric	Light density lithic scatter	None	None
47.17.04.02	Prehistoric	Light density lithic scatter	None	None
47.17.04.03	Prehistoric	Light density lithic scatter	None	None
47.17.04.04	Prehistoric	Petroglyphs	None	None
47.17.04.05	Prehistoric	Light density lithic scatter	None	None
48.17.33.01	Prehistoric	Lithic scatter	None	None
48.17.33.02	Prehistoric	Medium density lithic scatter	Elko series	Middle Archaic
48.17.33.03	Prehistoric	Light density lithic scatter	None	None
48.17.33.04	Prehistoric	Rock feature, petroglyph	Humboldt	Early Archaic
48.17.33.05	Prehistoric	Light density lithic scatter	None	None
48.17.34.01	Prehistoric	Obsidian quarry, lithic scatter, petroglyphs, rock features	None	None
48.17.34.04	Prehistoric	Medium density lithic scatter	None	None
48.17.34.05	Prehistoric	Light density lithic scatter	None	None
48.17.34.06	Prehistoric	Light density lithic scatter	None	None
48.17.34.07	Prehistoric	Light density lithic scatter	None	None
48.17.34.08	Prehistoric	Light density lithic scatter	None	None
48.17.34.09	Prehistoric	Light density lithic scatter	None	None
48.17.34.10	Prehistoric	Light density lithic scatter	None	None
48.17.34.11	Prehistoric	Light density lithic scatter	None	None
48.17.34.12	Prehistoric	Medium density lithic scatter	None	None
48.17.34.13	Prehistoric	Light density lithic scatter	None	None
48.17.34.15	Prehistoric	Lithic scatter	None	None
48.17.34.16	Prehistoric	Light density lithic scatter	None	None
CA-MOD-233/H	Prehistoric, historic	Lithic scatter, historic refuse, historic buildings	None	None
CA-MOD-5981	Prehistoric	Medium density lithic scatter	Elko series, Rose Spring	Middle-Late Archaic
CA-MOD-5982	Prehistoric	Sparse lithic scatter	NSN	Post Mazama
CA-MOD-5983	Prehistoric	Medium density lithic scatter, groundstone	Great Basin Stemmed, Elko , Rose Spring	Early Holocene, Middle-Late Archaic
CA-MOD-5984	Prehistoric	Sparse lithic scatter	Rose Spring	Late Archaic
CA-MOD-5985	Prehistoric	Medium density lithic scatter	Elko series	Middle Archaic
CA-MOD-5986	Prehistoric	Light density lithic scatter	Rose Spring	Late Archaic
CA-MOD-5987	Prehistoric	Dense lithic scatter	Rose Spring	Late Archaic

Table 2 (Continued)

Site Number	Type	Description	Temporal Markers	Tuscarora Sequence Temporal Association
CA-MOD-5988	Prehistoric	Sparse lithic scatter	Elko series	Middle Archaic
CA-MOD-5989	Prehistoric	Medium density lithic scatter, groundstone	Rose Spring	Late Archaic
CA-MOD-5990	Prehistoric	Sparse lithic scatter, groundstone, hunting blind	None	None
CA-MOD-5991	Prehistoric, historic	Lithic scatter, historic refuse	Elko series	Middle Archaic
CA-MOD-5992	Prehistoric	Sparse lithic scatter	None	None
CA-MOD-5993/H	Prehistoric, historic	Dense lithic scatter, groundstone, historic refuse	Humboldt, Elko series, Rose Spring	Early-Late Archaic
CA-MOD-5994	Prehistoric	Sparse and defuse lithic scatter	None	None
CA-MOD-5995	Prehistoric	Dense lithic scatter, groundstone, petroglyph	None	None
CA-MOD-5996	Prehistoric	Medium density lithic scatter	None	None
CA-MOD-5997	Prehistoric	Sparse lithic scatter	None	None
CA-MOD-5998	Prehistoric	Dense lithic scatter, groundstone, petroglyph, circular rock feature	Elko series	Middle Archaic
CA-MOD-5999	Prehistoric	Dense lithic scatter, petroglyphs, 3 hunting blinds	None	None
CA-MOD-6000	Prehistoric	Defuse lithic scatter	None	None
CA-MOD-6001	Prehistoric	Light density lithic scatter	None	None
CA-MOD-6611/H	Prehistoric, Historic	Lithic scatter, historic refuse	Rose Spring, Elko series	Middle-Late Archaic

stemmed point from the Early Holocene coupled with Elko and Rose Spring material from the Middle and Late Archaic, one site has material which spans the Archaic period, one that falls into the Post Mazama period, and one dates to the Early Archaic.

In sum, the data presented in Table 2 indicates that all of the previously recorded archaeological sites in the northern Cowhead Basin can be characterized by either lithic tool production or by petroglyphs, all of which support a hunting focus in the use of the region by Native Americans. Table 2 also illustrates that 88% of the previously documented archaeological sites can be characterized by a Middle to Late Archaic occupation.

Cowhead Slough Archaeological Survey Methodology and Results

As indicated by the literature review and the previously documented archaeological sites, much of the archaeology is the northern Cowhead Basin is geared toward hunting and hunting related activities. For the most part, previous archaeological surveys within the Basin consist of stratified, random sample surveys using 100 meter wide transects. A total of 561 acres were inventoried as a result of these previous inventories.

The 2007 Cowhead Archaeological Survey systematically surveyed an additional 50 acres. This survey resulted in the documentation of 11 previously unrecorded archaeological sites (Dalton 2007). The 2007 survey area and subsequent archaeological sites can be seen in Figure 9. Table 3 provides an account of each newly documented archaeological site and gives a brief description of each site. Similar to Table 2, Table 3 provides the site number in column one, site type is given in column two, column three gives a brief description of the site, column four indicates any temporally diagnostic projectile points documented at the site, and column five provides the corresponding Tuscarora temporal period assigned to the each diagnostic artifact.

Of the 11 newly documented archaeological sites, ten contain a lithic component, one is comprised solely of rock features, two are in association with petroglyphs, and eight contain either rock features or hunting blinds. There are

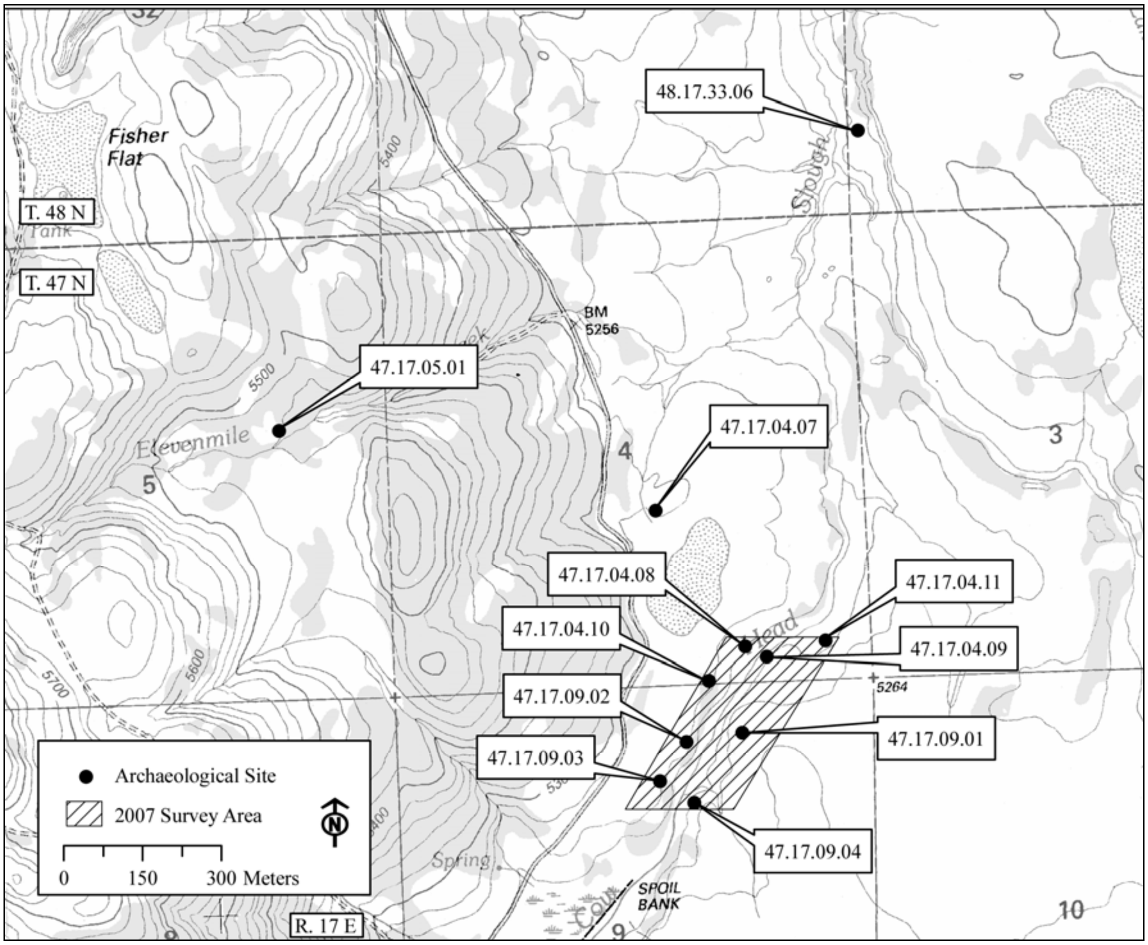

Figure 9. Cowhead Slough survey area and newly documented archaeological sites.

Source: Adapted from United States Geological Survey, 1990, Lake Annie Quadrangle, California 7.5 Minute Series Provisional Edition., Reston, VA: United States Geological Survey.

temporally diagnostic projectile points associated with five of these sites, which span the Archaic, with the majority falling into the Middle and Late Archaic periods. Two archaeological sites, 47.17.05.01 and 48.17.33.06, recorded in 2007 are outside of the survey area and therefore will not be included in the data analysis discussed in Chapter V.

The data presented in Table 3 shows that all of the archaeological sites recorded during the 2007 survey are generally associated with lithic tool production,

Table 3. Archaeological Sites Recorded During the 2007 Cowhead Slough Archaeological Survey.

Site Number	Type	Description	Temporal Markers	Tuscarora Sequence Temporal Association
47.17.04.07	Prehistoric	Light lithic scatter	Humboldt	Early Archaic
47.17.04.08	Prehistoric	Light lithic scatter	Rose Spring	Late Archaic
47.17.04.09	Prehistoric	Defuse lithic scatter, rock features	None	None
47.17.04.10.	Prehistoric, historic	Light lithic scatter, rock features, historic refuse	None	None
47.17.04.11	Prehistoric	Small lithic concentration, rock features	None	None
47.17.05.01	Prehistoric	Three lithic concentrations	Humboldt, Elko series	Early-Middle Archaic
47.17.19.01	Prehistoric	Medium density lithic scatter, rock features	Rose Spring, Elko series	Middle-Late Archaic
47.17.09.02	Prehistoric	Small lithic activity area, petroglyph, rock features	None	None
47.17.09.03	Prehistoric	Light lithic scatter, rock features	None	None
47.17.09.04	Prehistoric	Rock features	None	None
48.17.33.06	Prehistoric	Lithic scatter, groundstone, petroglyph, rock features	Elko series, Rose Spring	Middle-Late Archaic

petroglyphs, and rock features/hunting blinds, and for the most part date to the Middle or Late Archaic. Similar to the results from the previously recorded archaeological sites, these results suggest that hunting activities during the Middle and Archaic periods drove the use of the region.

The 2007 survey strategy encompassed the entire Cowhead Slough drainage, associated rock outcrops, and extended 100 meters beyond the rock outcrops. This survey design took into account the slough itself, the terrace/rock escarpment zone, and the upper-tier zone above the slough and terrace. The zone immediate to the Cowhead Slough resulted in little archaeological material. This lack of material is likely due to the hydrology and sedimentation of the stream. Only two archaeological sites (47.17.04.08 and 48.17.33.06) were documented within this zone. Both sites were situated on slightly raised outcrops and contained three hunting blinds and three projectile points. The projectile points within these sites date to Middle Archaic and Late Archaic temporal periods.

The terrace zone encompassed the majority of rock outcrops within the survey area and contained all the petroglyphs, while the upper-tier zone contained the majority of archaeological material. Archaeological material within the upper zone consisted of lithic scatters, associated projectile points, and rock features.

Rock features comprised a major component of the archaeological newly documented archaeological sites. In fact, the 11 archaeological sites recorded in 2007 contained 44 rock features. Of the 44 rock features documented during the 2007 survey, 23 fit the criteria developed for hunting blinds. Stone hunting blinds features generally have an inside diameter of one to one and a half meters, and are constructed two to three rock courses high. Images of two stone hunting blinds from Cowhead Slough are provided in Figures 10 and 11.

The environment around Cowhead Slough is composed of the forested Warner Mountains to the west, which supply the basin with snow run-off late into spring. To the east is the sprawling openness of the Great Basin. Cowhead Lake, a the large water catchment area is to the south. All of these factors contribute to be make the Cowhead Basin an ideal location for the pursuit and capture of large game. On numerous occasions during the 2007 survey, the author of the thesis and Bureau of Land Management Archaeologist Penni Borghi saw artiodactyls in northern Cowhead Basin. In fact, Ms.

Figure 10. Stone hunting blind at site 47.17.09, overlooking Cowhead Slough.

Borghi and I even startled a pair of pronghorn as they approached a break in the escapement while we were recording a hunting blind. The nature of the archaeological material in the northern Cowhead Basin and the availability of high-ranking prey items within the region suggests that hunting activities factored prominently into the use of the area by prehistoric hunter gatherers.

Chapter Summary

This chapter has summarized the natural environment of the Cowhead basin. It has shown that the Cowhead basin provided exceptional habitat for artiodactyls, which pronghorn and mule deer make the most use of. Previous biological and herd

Figure 11. Stone hunting blind with Cowhead Slough in the background, from site 47.17.04.09.

management research in the region has indicted that the Cowhead basin is a migration destination and kidding ground for pronghorn, and that the region serves as winter habitat and a kidding location for mule deer. This chapter has also presented data on the 2007 BLM Cowhead Slough archaeological survey.

The previously completed archaeological studies and archaeological sites discussed in this chapter have shown that the archaeology within Cowhead Basin is rich with lithic scatters, rock features, groundstone deposits, and petroglyphs. The next chapter, Chapter V, will introduce the analytical methodology used in this study. It will also provide a discussion of why each analytical technique was used and furnish step-by-step descriptions of the application of each technique. The goal of Chapter V will be to illustrate how these methods can be employed to address questions pertaining to hunter-gatherer group size and social organization.

CHAPTER V

ANALYSIS OF SPATIAL POINT PATTERNS

The preceding chapter concluded with a discussion of the results of the 2007 Cowhead Slough archaeological survey. Building on those results, this chapter will outline the analytical laboratory analyses that were applied to the field data in an effort to test the relationship between forager group size and the archaeological record. The data used in this consists of 23 hunting blinds, which comprise a spatial point dataset. The spatial point analyses introduced and employed will test the expectations outlined in Chapters II and III. These expectations are: that hunting blinds will cluster in numbers consist with those derived from the optimal group size model, and that they will be spaced in accordance with the optimal performance of the bow and arrow.

The first part of this chapter will introduce the field of spatial point analysis and discuss its place in modern archaeology. The methods used in spatial point analyses are among the most widely accepted in archaeological research (Kelly 1992:44); they provide insight into issues relating to forager mobility and settlement (Binford 1980), resource procurement (Beck and Jones 1990), and interassemblage variability (Binford 1973).

The second part of this chapter will focus the role of geographic information systems in archaeology, and the following three sections will discuss the three analytical methodologies utilized in this research: cluster, spider, and nearest neighbor analysis. Each section will demonstrate why the particular analytical procedure was chosen and how it will contribution to this study's goal of accessing the value of foraging theory to understanding the geographic placement of stone hunting blinds by prehistoric hunter gatherers. The chapter will conclude with a discussion of the results produced through the combination of the three methodologies.

Spatial Point Analyses and Archaeology

Spatial point analyses utilize mathematical models that depict the arrangement of objects, known as points, in a defined space. Archaeology is one of the classic disciplines using spatial point analyses; applications of spatial point analyses with the discipline are commonly referred to as settlement, regional, or landscape studies (Illian 2008:XI). The interpretation of spatial patterning among and within archaeological sites plays an important role in archeological interpretation, aiding archaeologists in understanding the connectedness of the archaeological landscape (Banning 2002; Binford 1978; Gargett and Hayden 1991:11; Kroll and Price 1991:1).

Traditionally, spatial questions in archaeology have focused on site structure and settlement patterns (Kroll and Price 1991:2). However, in recent decades there has been a considerable increase in the topics and methodology employed to ascertain answers to a wide-range of spatial questions set in an assortment of archaeological contexts, including questions related to sociopolitical organization, site abandonment, subsistence, and hunting strategies (Kanter 2007:43). Muir and Driver (2002) employ several spatial scales of analysis from the household unit up to the regional level to identify patterns of faunal remains in the San Juan region of the American Southwest. Some recurrent themes addressed through spatial analysis include long distance trade and migration, and the distribution of material remains to identify sociopolitical boundaries (Geib 2000; Kulischeck 2003).

The use of spatial techniques and models in archaeology offers researchers a quantitative methodology that allows for a complex understanding of human relationships with one another and with the physical environment across space (Kanter 2007:38). In recent years, the coalescence of evolutionary theory with regional analyses in archaeology has diversified the traditional methods of spatial analysis used by archaeologists; this has been fueled by the proliferation of geographic information systems (Kanter 2007:50). Spatial studies in archaeology have matured beyond the use of basic mathematical and geographical measures into a diverse toolkit of intricate techniques that accurately inform the archaeological record (Kanter 2007:37).

Geographic Information Systems and Archaeology

The advent of geographic information systems has been toted as "…the biggest step forward in the handling of geographic information since the invention of the map" (Department of the Environment 1987:8). The purpose of this section is to demonstrate the value of geographic information systems in archaeology and illustrate its contributions through the use of case studies, which test the tenets and expectation of foraging theory.

A geographic information system is comprised of computer hardware and software designed to proficiently capture, store, update, manage, analyze, and display all forms of geographic information (Rhind and Connolly 1990:2). Data contained in geographic information systems are stored in a spatial data format known as a shapefile. Shapefiles store the geometric position and attribute information of geographic features (Wade and Sommer 2006:191).

The true strength of a geographic information system lies in its analytical capacity (Goodchild 1992). The numerous spatial-statistical tools contained within geographic information systems have the ability to integrate a range of spatial information in coordination with descriptive attribute data (Lock 2003:163). Through the creation of conceptualized models of the physical world geographic information systems can represent simplified aspects of complicated realities, which allow for better conceptual realization of many scientific questions, including those related to natural and human environments (Lock 2003:147; Longley et al. 2005:39-40).

The use of geographic information systems in archaeology is most commonly associated with cultural resource management and the management of archaeological resources. This is a result of the capacity of geographic information systems for managing spatially associated databases. Spatially associated databases are designed to capture and query data pertaining to morphology and topology; attribute-only databases cannot (Conolly and Lake 2006:34). From a cultural resource management perspective the benefits of having an integrated database system that promotes the integration of archaeological sites within a larger spatial context are huge (Conolly and Lake 2006:34).

Over the last decade geographic information systems have become integrated into archaeological theory (Chapman 2006:9; Conolly and Lake 2006:3; Lock 2003). The interdisciplinary nature of modern archaeology prompted archaeologists to recognize the potential of geographic information systems in addressing archaeological questions. Regional archaeologies such as landscape archaeology and those dealing with settlement patterns have advanced tremendously through the large-scale geographic modeling of archaeological and environmental data (Chapman 2006:128).

Morgan (2008) utilized a geographic information system in association with foraging theory to reconstruct the foraging patterns of prehistoric Western Mono hunter-gatherers within the southern Sierra Nevada Mountains of California. This study employed s geographic information system to analyze dispersion and travel cost associated with hunter-gatherer movement between caching features and residential sites (Morgan 2008:247). Morgan (2008:254) found that the mean distances from habitation settlements to caches within the Western Mono foraging territory were bimodal, peaks occurred 0.5 kilometers (km) and 5.0 km, and 6.0 km and 8.5 km. According to Morgan, this study indicates that the Western Mono employed a two-part foraging strategy founded on the sustainability winter group aggregations while also allowing for spring and summer mobility. The results from this study "…show the efficiency of using point features and simple geographic information systems based spatial analyses to reconstruct prehistoric foraging radii and provide the means to model the energetics of different foraging behaviors" (Morgan 2008:247).

McGuire and colleagues (2007) employ a geographic information system model to establish caloric returns rates for large game hunting during the Middle Archaic in the Owens Valley, California. This study incorporated a geographic information system based least-cost algorithm to model the caloric investment required for a foraging trip originating at a hypothetical residential base situated on the Owens Valley floor and requiring travel to and from the upland hunting grounds of White Mountains (McGuire et al. 2007:361). The results of this study indicate that the caloric requirements associated with a round trip foraging expedition to the White Mountains far exceeded the caloric returns of such a trip (McGuire et al. 2007:361). Thus, the authors conclude that there may have been a shift in the motivation for the hunting large game in the region during the Middle Archaic (McGuire et al. 2007:363). Although these conclusions have been called into question (Grimstead 2009), this study represents an example of the use of a geographic information system in archaeology.

In a similar study, Arroyo (2008) uses foraging theory and a geographic information system to explore the relationship between travel time and the caloric returns associated with red deer and ibex in eastern Spain. Arroyo (2008:31) incorporates the caloric values associated with a red deer and ibex into a geographic information system model, which accounts for the maximum distance a forager could travel based on the caloric returns proved from each animal. Contrary to McGuire and colleagues (2007), Arroyo concludes that it is "… precisely the maximization of the ratio of energy contributed to energy expended that controls and modifies human hunting decisions" (Arroyo 2008:34). This study provides an illustration of how the models of foraging theory can be tested using a geographic information system (Arroyo 2008:34).

Today, geographic information systems are firmly imbedded within archaeological theory and interpretation. Through the representation of data, its ability to integrate numerous data types, and its analytical capabilities, geographic information system technology has the ability to reinvent several of the existing the practices in archaeology, as well as advance many new and exiting ones (Lock 2003: 268). The suite of statistical tools contained in geographic information systems, such as spider diagrams, cluster analysis and nearest neighbor analysis, play a vital role in the quantitative research methodology of many archaeologists (Lock 2003:166).

Spider Analysis

A spider analysis creates a series of lines that provide either Euclidean or Manhattan distance to and from all points in an analysis. The resulting spider diagram is an effective way to display and evaluate the distribution of data points within an analysis (Howse et al. 2000:26). The central application of spider analysis has been to aid the development of marketing strategies and planning scenarios. Spider analysis is a tool used to collected distances. In this study, the distances gathered from the spider analysis will aid in the testing of each of the expectations.

The use of spider analysis in geographic information systems is rather recent. However, there are numerous scripts (i.e., statistical package extensions for geographic information systems) that can be downloaded and applied point based datasets. This research utilizes a script developed by Laura Wilson in 2005. This script is designed specifically for use with the Environmental Systems Research Institute (ERSI) ArcGIS software (arcscripts.esri.com).

Geographic information system based applications of spider analysis in archaeology are still in their infancy. Wood and Wood (2006) apply a modified version of a spider analysis to assess the energetic costs of prehistoric human travel across various terrains. In the Woods' study, both shortest path and most optimal path to sixteen destinations were calculated. Taking into account the terrain's elevation and slope, the traveler's body weight, sex, stride, and speed of travel the authors were able to determine the most efficient routes of travel across a particular landscape (Wood and Wood 2006).

The application of a spider analysis in my study is for the purpose of providing distances between the hunting blinds documented during the Cowhead Slough archaeological survey. While these distances are not illustrative in and of themselves they are a vital aspect of the cluster and nearest neighbor analyses, which will utilize the distances in the creation of statistically derived clusters.

Cluster Analysis

Cluster Analysis refers to a collection of mathematical techniques that can be used to determine the relationships of objects in a dataset by way of grouping similar objects into subgroups known as clusters (Lorr 1983:1; Romesburg 1984:2, 15). Cluster techniques create classification systems in which the number and nature of the data groupings are not known to the analyst prior to analysis (Lorr 1983:1). There is grouping are created based on the similarities in the data. The mathematical models used in cluster analysis number in the hundreds, and it is widely known that different models may generate different results when applied to the same data (Aldenderfer 1982:61; Lorr 1983:3; Romesburg 1984:2). For this reason researchers utilizing cluster techniques must take special care in selecting the technique best suited for the needs of their study.

This research uses a hierarchical cluster analysis. Of the clustering techniques a hierarchical cluster analysis is the most widely accepted and regularly used cluster method (Cowgill 1968:369; Romesburg 1984:3). Spatial applications of a hierarchical cluster analysis are frequent. These applications utilize inter-object Euclidean distance to create a multilevel diagram known as a dendrogram, which illustrates the hierarchy of similarity among the data (Romesburg 1984:3). The spatial nature of this research and its usage of inter-object Euclidean distance make the application of a hierarchical cluster analysis the most appropriate cluster technique.

Cluster techniques have been used in archaeological research for nearly half a century (Aldenderfer 1982:61). The division of data into subgroups based on similarities is a critical stage in archaeological analysis that should be completed as objectively as possible (Hodson 1970:299). The numerical methods used in cluster analysis and the precision and accuracy by which it completes the task of data grouping make it a valuable tool for archaeologists.

The hierarchical cluster analysis employed in this study will provide statistically derived groupings of hunting blinds, which will be compared with expectations generated from foraging theory and the optimal group size model. If the results of the hierarchical cluster analysis fall within the range of expectations set forth by the optimal group size model regarding the optimal caloric gains for the individuals associated with large game hunting parties then the model will be supported. Once the cluster analysis is completed a nearest neighbor analysis will be completed utilizing the hunting blinds.

Nearest Neighbor Analysis

Nearest neighbor analysis is a technique for exploring patterns in data through the comparison of the observed patterning in a dataset to that of expected spatial randomness (Bailey 1994:25). Fundamentally, the nearest neighbor technique is a method of cluster analysis. However, unlike a hierarchical cluster analysis, nearest neighbor is a single level analysis in which the relatedness of objects is expressed in the form of an index (Environmental Systems Research Institute 2009; Lorr 1983:62). The nearest neighbor index represents the ratio of the observed distance divided by the expected distance. The expected distance is the average distance between neighbors in a hypothetical random distribution. If the index is less than one, the data exhibits clustering; if the index is greater than one, the data is considered dispersed (Environmental Systems Research Institute 2009).

Clark and Evans (1954:445) first demonstrated the value of nearest neighbor analysis in ecology, as a method for interpreting the distribution of plants and animal in the natural environment. Not long after, geographers and archaeologists began applying the technique to studies of contemporary and archaeological settlement patterns (Corley and Hagget 1965; Hodder 1972). Today, nearest neighbor analysis is a preferred technique for many archaeologists. Its popularity is due in part to straightforward mathematical calculations and an easily interpreted coefficient (Conolly and Lake 2006:164).

Within this study nearest neighbor served two purposes: first to validate the results of the hierarchical cluster analysis by demonstrating via a second clustering method that the data points are clustered on the landscape, and second to determine intra-feature distance. The initial application of nearest neighbor to validate the results of the cluster analysis was conducted independent of the spider and hierarchical cluster analyses. In this instance the nearest neighbor analysis was autonomous from the other techniques because it derived the distances and cluster composition independently of the both the spider and cluster analyses.

One of the qualities of nearest neighbor is that it provides researchers with an average distance to the nearest neighbor. The goal of the second phase of the nearest neighbor is to ascertain intra-feature distance within individual clusters. This application utilizes the clusters created from the hierarchical cluster analysis in order to derive the average distance to nearest neighbor within each cluster.

The goals of section were to introduce the analytical methods used in this study and explain how they will contribute to this research. Thus far this chapter has introduced graphic information systems and discussed how archaeological research and database management have benefited from the application geographic information systems. This chapter has presented three analytical procedures commonly employed to interpret the degree of clustering in a sample within the field of spatial point pattern analysis. It has also presented the contributions of these analytical tools within archaeology. The final section of this chapter will outline the analytical steps as applied to the Cowhead Slough survey results, and present the results of the research.

Cowhead Slough Survey Analytical Methodology and Results

The goal of section is to discuss how the analytical techniques outlined above were applied to the Cowhead Slough survey results. The section will clarify the use of the spider and cluster methods used in this study and demonstrate how they were joined to construct an interpretation regarding the spatial placement of prehistoric hunting features in the Cowhead Basin. It will also explain the use and value of a nearest neighbor analysis to this research, both as a cluster validation technique and for assessing the spatial associations of the features in this study. The first step in the analysis of the Cowhead Slough dataset was to complete a spider analysis.

Spider Analysis Results

As previously discussed, a spider analysis is a valuable tool for providing distance from one feature to all other features in an analysis. The spider tool is an uncomplicated tool that provides only distance. Since this research is based on the distribution of 23 hunting blinds across the landscape, the accurate collection of distance measurements between all data points was a critical first step (Figure 12). Simply put a spider analysis provides a spatial proximity assignment for each case to all other cases in an analysis.

This research utilized a spider script developed by Wilson (2005). Wilson's spider script created geographic information system a line shapefile and an associated database comprised of some 506 distance measurements (Figure 13).

The spider database provided information pertaining to the feature of origin and insertion feature for each of the 506 lines, along with a total distance for line. While the 506 lines connected the 23 hunting blinds, data pertaining to their spatial proximity to one another was contained in the associated database. These data are contained in Appendix A. This appendix consists of a table, which summarizes the results of the spider analysis. Column one provides the feature of origin for each spider line. Column two provides the destination feature for each spider line. Column three given the length of each spider line, and column four provide the origin and destination identification number for individual spider lines.

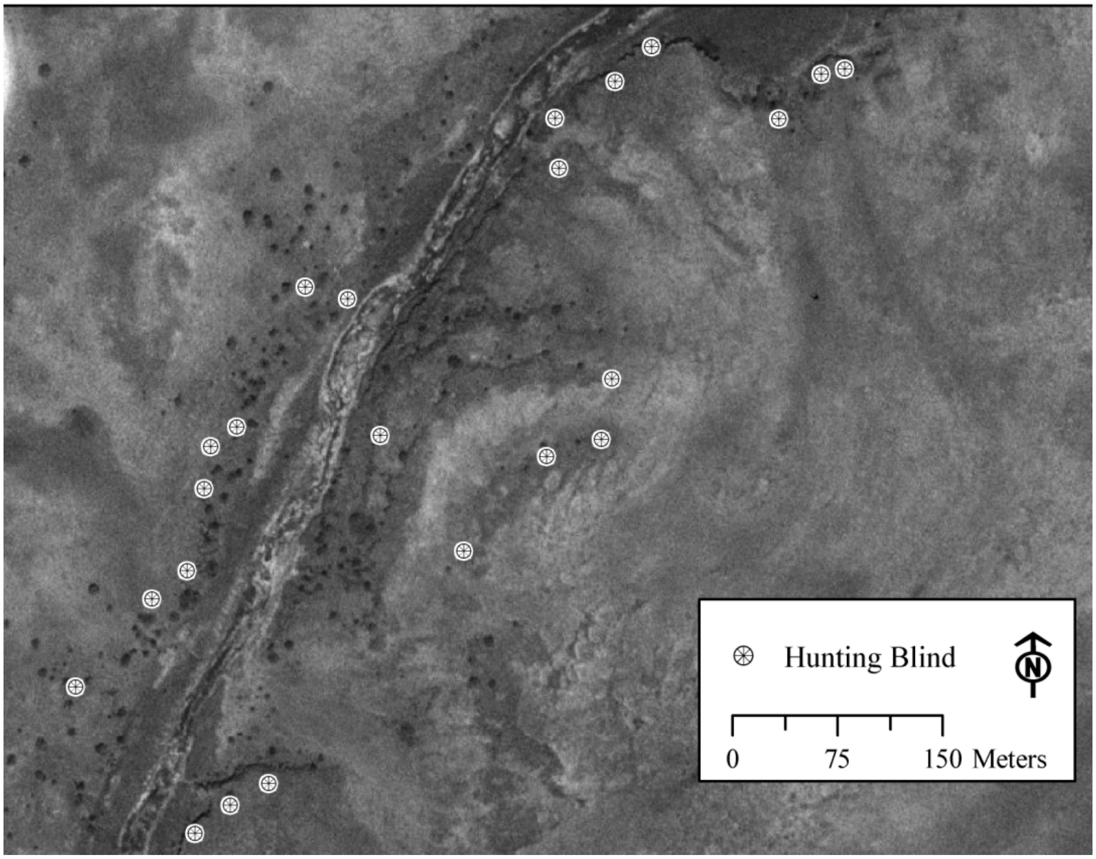

Figure 12. Digital Orthophoto Quadrangle (DOQ) of survey area illustrating the location of the hunting blinds included in the analytical analysis.

The next step subjected the results of the spider analysis to a cluster analysis. To complete the hierarchical cluster analysis the database containing the results of the spider analysis was exported out of the geographic information system and imported into the computer based statistical package for the social sciences version 18 (SPSS 18). It is important to note that only the spider database was exported the geographic information associated with the spider analysis remained part of the original spider shapefile, because later in the analysis, the results of the cluster analysis would have to be combined with spider shapefile and attached to the appropriate hunting blind in order to be view and interpreted in the geographic information system.

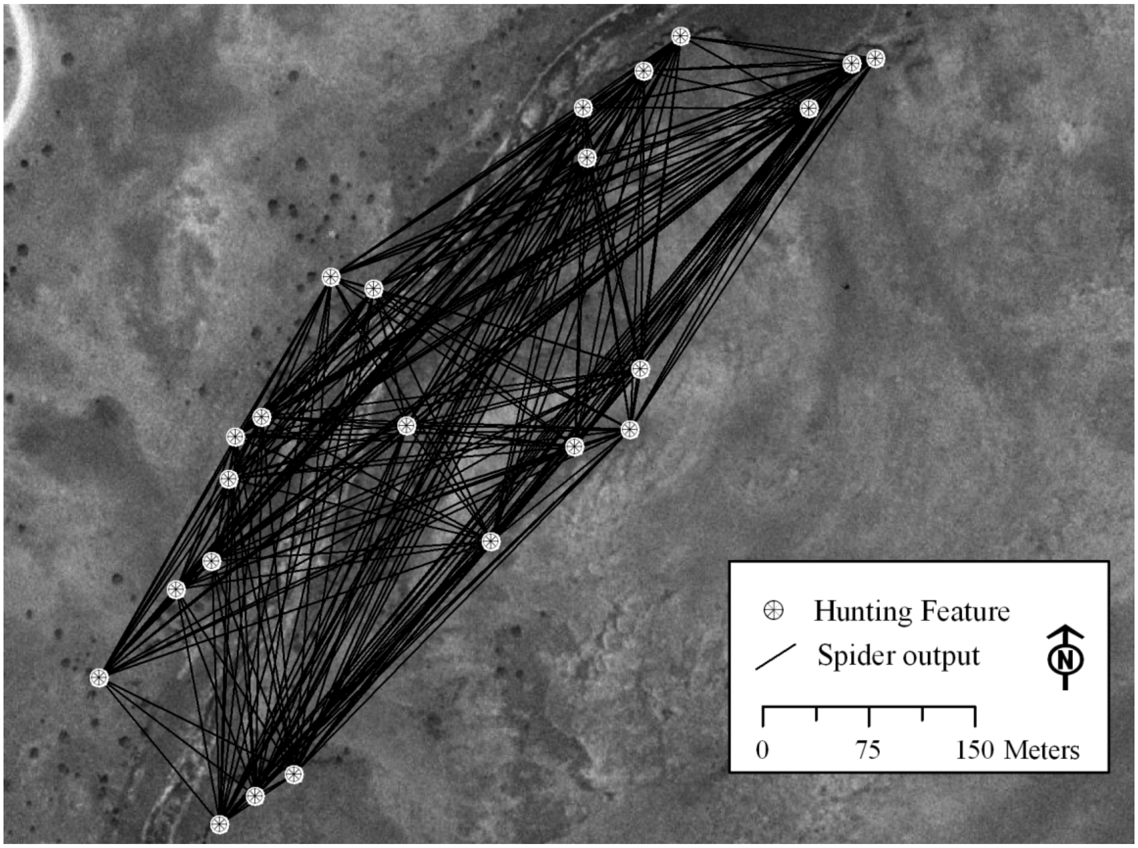

Figure 13. DOQ of survey area showing the results of the spider analysis.

<u>Hierarchical Cluster Analysis Results</u>

Hierarchical cluster analyses group data based on the similarity of selected attributes. This method of cluster analysis was applied to the results of the spider analysis in order to ascertain patterns or clusters in the data based on the relative distance of each individual point to all others in the analysis.

The hierarchical cluster analysis within SPSS 18 utilizes a technique known as agglomerative hierarchical clustering (Norusis 2010:363). This algorithm begins by placing each case into its own cluster and then combines the cluster until only one remains. The variable(s) selected to characterize the clusters determine when the significant grouping have been achieved (Norusis 2010:364).

The application of hierarchical cluster analysis in this study was relatively simple. The only variable used to generate clusters was distance. Using distance as a variable to define clusters is common and frequently referred to as a proximity analysis (Norusis 2010:366). The hierarchical cluster analysis utilized the 506 distances generated from the spider analysis to create a dendrogram that placed the hunting features into statistically derived groups, assigning each distance a number that corresponded to a given cluster of hunting blinds.

As mentioned above, the cluster results then had to be imported back into the geographic information system and merged with the original spider shapefile database. The merging of the cluster results with the original spider database in the geographic information system was necessary because the spider shapefile retained all the geographic location information for the hunting blinds. This step in the analysis required a carefully review of the origin and insertion data from the spider database in the geographic information system. Each line was then attached to the correct feature of origin and insertion in the geographic information system database in order to restore its proper geographic position. The resulting geographic information system database not only contained information for the origin and insertion of the 506 spider-lines, but it also included a new column that indicated which cluster the hierarchical cluster analysis placed the point of origin of each line from the spider-line database into.

The hierarchical cluster analysis placed the 23 archaeological hunting features into five clusters. The results of the cluster analysis showed the number of clusters and size of each cluster in the dataset. These clusters ranged in size from three to seven hunting features. The cluster grouping were as follows: cluster one contained seven features, cluster two was comprised of three features, cluster three included three features, cluster four contained six hunting features, and cluster five consisted of four features (Figure 14).

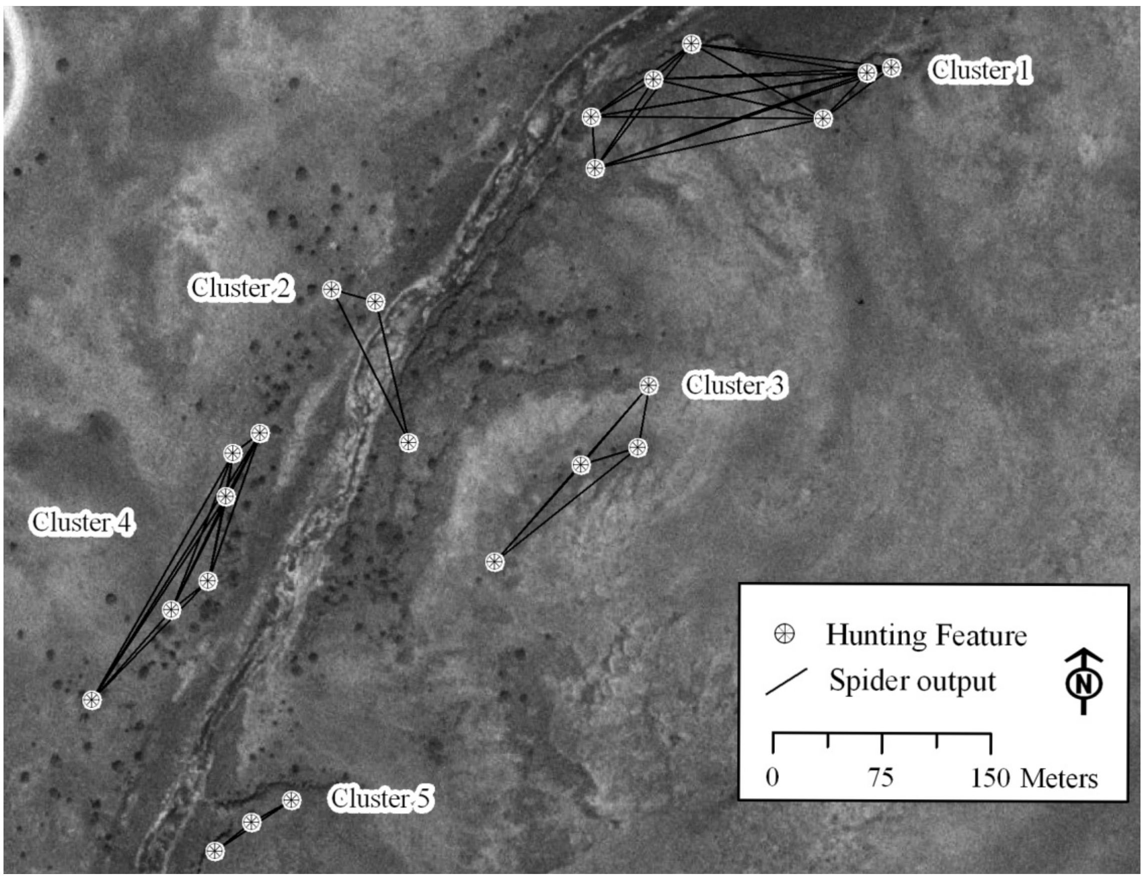

Figure 14. DOQ illustrating the location of clusters and number of hunting blinds associated with each cluster.

Cluster one is the northernmost cluster in the analysis. This cluster consists of seven hunting blinds and is completely contained on the east side of Cowhead Slough. This cluster appears to consist of two loci. Four of the hunting blinds within the cluster have a northeastern aspect, while three have a northern aspect. Based on the spatial separation and aspect differences, cluster one may consist of two smaller hunting clusters comprised of four and three blinds respectively.

Cluster two consists of three hunting blinds. This cluster spans Cowhead Slough, with two binds located to the west of the slough and one to the east. While the blinds in this cluster appear to be at similar elevations, the eastern bind could be part of cluster three, to the east.

Cluster three is farthest group from the Cowhead Slough, at a distance of about 75 meters. The cluster is comprised of four hunting blinds. These binds are situated on a slight knoll and for the most part face north, south, and west.

Cluster four is completed contained on the western side of Cowhead Slough. This cluster is longest north/south trending cluster in the analysis, spanning a distance of 218 meters. It is comprised of six hunting blinds, each having either a northeastern or southeastern aspect.

Cluster five is the southernmost grouping in the analysis. This cluster is located on the east side of Cowhead Slough and consists of four hunting blinds. The blinds are situated on a raised rock outcrop that overlooks the slough to the northwest.

The final step in this phase was to isolate and select individual clusters out of the updated geographic information system database. The purpose of this step to create individual shapefiles for each cluster to allow for an independent nearest neighbor analysis to be completed on each of the five clusters, and to allow for a better visual representation of each cluster created from the hierarchical cluster analysis. This was accomplished in geographic information system by selecting all features associated with a single cluster and creating a new shapefile based on the selections. For example, all seven features associated with feature one were selected and copied into a new shapefile containing only those features.

The hierarchical cluster analysis and its results are based solely on the Euclidean space among the hunting blinds and do not take into account other factors such as, topography, and survey design and implementation, which may influence the geographic placement of hunting blinds. Survey strategy design can influence the apparent clustering of features on the landscape. Take for example a survey that covers a swath of the Great Basin eight miles long and half-a-mile wide. Within the survey area there is a linear drainage, which the survey crosses over. Although, the survey only covers a small portion of the drainage there are likely to be a high ratio of archaeological sites within the vicinity of this topographic feature. The results of the survey would likely indicate that the archaeological sites indentified tend to cluster near the water source. In contrast, the Cowhead Slough survey design only encompasses the Cowhead Slough drainage, the associated rock escarpment, and an adjacent 100 meter area on either side of the escarpment, areas where archaeological sites will likely concentrate. Essentially, the entire Cowhead Slough survey occurs within an area that what would likely be interpreted as an archaeological cluster by other surveys. Therefore, nature of this survey and its design make it ideal for investigating questions pertaining to archaeological site patterning and the distribution of hunting blinds.

Geographic topography is known to influence to archaeological patterning and site location (Binford 1978; Redman and Watson 1970; Stiner 1990), and likely contributes to the location of hunting blinds on the landscape. For the most part, predatory animals rely on the landscape and surrounding vegetation to facilitate the capture of prey items (Stiner 1990:332). Topography can create aggregations of game and in some locations can be used to direct game to into specific areas (Binford 1978:346, 392). In short, ambush or surprise hunting strategies, such as those employed by hunters using hunting blinds require a high-quality location for game interception (Stiner 1990:332).

Nearest Neighbor Results

The third phase of analysis involved a nearest neighbor analysis. The first goal of the nearest neighbor analysis was to validate the results of the hierarchical cluster, this application was completed independent of the spider analysis and hierarchical cluster analysis. The second goal was to first to determine intra-feature distance within the clusters generated by the hierarchical cluster analysis.

There are several algorithms associated with nearest neighbor queries, which can all be defined as techniques that facilitate the finding of the closest object (*k*) in space (*S*) to a specific query object (*q*) (Hjaltason and Samet 2003:529). This research utilizes tree-based Euclidean distance technique for spatial indexing commonly referred to as a quadtree. Quadtrees prioritize objects in space by placing them into a series of blocks of space (Tanin et al. 2005:85). The area incorporated in the analysis is divided into four equal regions, each of these four regions are then divided into four sub-regions. The successive regions of continue to be subdivided until all objects in the analysis are indexed (Longley et al. 2005:235). Figure 15 provides an example of a quadtree. The geographic information system then ranks the objects in hierarchical manner from closest

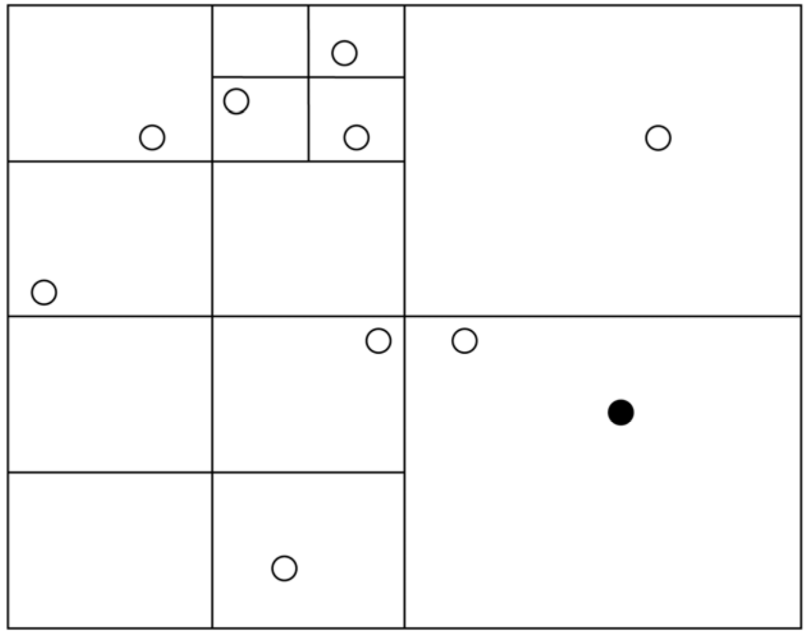

Figure 15. Example of a quadtree spatial index. The query object is indicated by the black circle.

to farthest from the query point, and prioritizes the query on the basis of these distances to establish a nearest neighbor.

The results of the nearest neighbor analysis are summarized in Table 4 and discussed the following paragraphs. The first column in Table 4 provides the cluster number. Column two provides the nearest neighbor ratio. You may recall if the nearest neighbor ratio is less than one, the data exhibits clustering, and if the ratio is above than one the data are considered dispersed. Column three provides the probability value (p-value) associated with each cluster. The p-value is a measure of consistency; it calculates the likelihood a study's results with the possibility of those more extreme. The p-value for nearest neighbor is calculated by comparing the observed feature distribution with that excepted from a random distribution. Column four indicates the average distance to nearest neighbor in meters within each cluster.

Table 4. Summary of Nearest Neighbor Results for the Entire Dataset and Individual Clusters.

Cluster Number	Nearest Neighbor Ratio	P-Value	Average Distance to Nearest Neighbor (meters)
Entire Dataset	0.95	0.66	44.45
Cluster 1	1.93	0.01	31.60
Cluster 2	1.80	0.03	31.50
Cluster 3	1.73	0.05	35.61
Cluster 4	2.30	0.01	37.39
Cluster 5	1.96	0.01	31.49

In order for nearest neighbor to access the degree of dispersion among the objects in a given dataset the spatial extents of the analysis must be properly characterized. In most cases, how the boundaries are determined is left to the discretion of the researcher, however the improper depiction of the spatial limits of the analysis can result in an unsubstantiated nearest neighbor outcome. If the spatial limits of the analysis are set to large then the data will appear clustered when they are not, and if the limits simply bound the objects within the analysis they may appear falsely dispersed.

This research uses the 2007 Cowhead Survey extents as the spatial boundary for the nearest neighbor analysis. This boundary is appropriate because it signifies the extent of the area covered by the survey, and is representative of both space with cultural remains and space without. As mentioned above in regards to the cluster results, the survey area is within a region that could be defined by other surveys as having a cluster of archaeological sites.

The nearest neighbor function was run on the entire dataset and then on the individuals clusters within the dataset. The goal of performing nearest neighbor on the entire dataset was to confirm the results of the hierarchical cluster analysis, while the aim of its application to individual clusters was to provide a measure of how the features within each cluster filled the geographic space occupied by each cluster.

The initial application of nearest neighbor to the Cowhead Slough dataset was completed on the entire dataset. The nearest neighbor ratio of the entire dataset was 0.95. Since this value for the entire dataset is slightly under one, the dataset exhibits slight clustering. However, these results are not statistically significant to the 0.05 level. This result confirms the results of the hierarchical cluster analysis, hunting blinds do cluster on the landscape.

As mentioned near the beginning of this section nearest neighbor also provides an average distance to an object’s nearest neighbor. The average intra-feature among all features in the analysis was 44.56 meters. After this initial application of nearest neighbor, the analysis was completed on the five clusters generated by the hierarchical cluster analysis to measure feature dispersion within each cluster, and to distance between features.

Cluster one produced a nearest neighbor ratio of 1.93. Since a value over one signifies dispersion, this result indicates that the hunting features that create cluster one are dispersed within the boundaries of the cluster. This result is statistically significant to the 0.05 level. The average intra-feature distance within cluster one is 31.60 meters.

The nearest neighbor ratio for cluster two is 1.80. This result is statistically significant and indicates that the hunting features in cluster two are dispersed within the boundaries of the cluster. The average intra-feature distance among the features in cluster two is 31.50 meters.

The nearest neighbor analysis of Cluster three resulted in a statistically significant nearest neighbor ratio of 1.73. Again, this result denotes that the hunting features creating cluster three are dispersed within the boundaries of the feature. The average distance to nearest neighbor among cluster three is 35.61 meters.

Cluster four produced a nearest neighbor ratio of 2.30. This result is statistically significant; the features within cluster four are dispersed. The average intra-feature distance among the features of cluster four is 37.39 meters.

The nearest neighbor analysis for cluster five produced a nearest neighbor ratio of 1.96, an indication that the hunting features within this cluster are dispersed. This ratio is statistically significant. The average intra-feature distance within cluster five is 31.49 meters.

Summary of Analytical Results

The results of the analytical analysis presented above are directly linked the expectations developed in Chapters II and III. The clustering of hunting blinds and the number of hunting blinds per cluster strongly supports a collective hunting strategy, and the predictions generated from foraging theory. In addition, the average distance among the hunting blinds within clusters seem to be spatially arranged in relation to hunting technology.

Chapter Summary

This chapter has spanned a considerable amount of material. It began by introducing the suite of methodological tools: spider analysis, hierarchical cluster analysis, and nearest neighbor analysis, which were employed in the analytical analysis of the Cowhead Slough archaeological survey results. This chapter then discussed how these methodological tools were sequentially applied to the Cowhead Survey results, creating a depth of analytical understanding regarding the spatial configuration of prehistoric hunting blinds.

The next chapter will provide a discussion of the analytical results presented in this chapter in the context of forager group size and hunting technologies. In addition, Chapter VI will discuss how the findings of this study address the research question and the expectation posed in Chapters II and III. The final goal of Chapter VI will be to provide conclusions and directions for future research.

CHAPTER VI

COLLECTIVE HUNTING STRATEGIES

AND HUNTING BLINDS

This study has applied evolutionary theory to a geospatial analysis of prehistoric hunting blinds in an effort to ascertain answers to questions pertaining to collective hunting strategies in the Cowhead Basin in the western Great Basin. This thesis sought to clarify why specific locations were selected for the construction of hunting blinds, determine if these features cluster on the landscape in a manner consistent with expectations derived from the optimal group model within foraging theory, and explain the importance of their spatial distribution within the prehistoric hunting landscape. The hypothesis posed at the onset of this study was that prehistoric hunting strategies would be shaped by a forager's drive to maximize their caloric intake, and that the forager would employ the most efficient methods possible to capture the highest-ranking animal resources available.

The central goal of this chapter is to systematically examine the results of the analytical analysis. These results will be evaluated against the expectations derived from the research hypothesis that have been developed earlier in this thesis. This chapter will provide a discussion the results my study. In addition, this chapter will supply a summary of my study and present my conclusions. The closing section of this thesis will offer some ideas for future research.

Temporal Association of Cowhead Slough Hunting Blinds

This study has shown the stone blinds, cairns, and linear alignments occur in considerable numbers throughout the Great Basin (Brook 1980; Delacorte 1985; Pendelton and Thomas 1983). A paramount issue associated with the analysis of stone features regardless of their nature is assessing the feature’s age. This process is made even more difficult by the likely continuous use of many stone features over long periods of time (Binford 1982; Brook 1980; Delacorte 1985; Pendelton and Thomas 1983). Bednarik (2002) provides a detailed description and critique of many of the techniques employed to date stone features, among these are excavation, proximity to diagnostic artifacts, surface patination and weathering of the stone surfaces, radiocarbon analysis of organic inclusions, and Lichenomertry.

The hunting blinds used in this study were dated using artifacts found in association with individual hunting blinds or in close proximity to hunting blinds. Within Chapter IV, Tables 1 and 2 summarized the archaeological sites and associated diagnostic projectile points within the northern Cowhead Basin. The temporal results indicated that the majority of archaeological material with the study area was generated during the later Middle Archaic (3,500-1,300 B.P.) and Late Archaic (1,300-600 B.P.) periods.

The later part of the Middle Archaic marks the initial appearance arrow points, which are known to have accompanied a major technological shift from the spear and atlatl the bow and arrow. Generally, within the western Great Basin this technological switch is thought to have occurred between 2,500 and 1,500 B.P. (Elston 1986:145; Hildebrandt and King 2004:24; Webster 1980:64). Based on the artifactual evidence from Cowhead Slough this research contends that hunting blinds at this locality were used during Late Archaic period in conjunction with the bow and arrow.

Evaluation of Expectations and Hypothesis

The goal of this thesis was to answer the question: to what extent were prehistoric hunting strategies shaped by forager group size and hunting technology? The hypothesis for set forth was that prehistoric hunting strategies would be shaped by a forager's drive to maximize their caloric intake. Chapters II and III developed two expectations stemming from this research hypothesis. These expectations may now be evaluated.

The expectation developed in Chapter II was that blinds would cluster in numbers consist with the expected optimal number of individuals for hunting party under the optimal group size model. A review of the ethnoarchaeological and ethnographic research pertaining to the optimal group size model indicated that the optimal forager group size when pursing large game was between four and seven individuals. To test this expectation I utilized a spider analysis and a hierarchical cluster analysis.

The spider analysis was utsed to derive distances from each hunting blind to all other hunting blinds in the analysis. The hierarchical cluster analysis was completed using the distances generated from the spider analysis. The hierarchical cluster analysis created five statistically derived hunting blind clusters. The results of which were verified using a nearest neighbor analysis. The cluster analysis indicated that hunting blinds at Cowhead Slough do indeed cluster on the landscape, and that they cluster in groups comprised of three to seven hunting blinds. These results are consists with expectation derived from the optimal group size model, that foragers pursue large game in groups of four to seven individuals. Thus, this expectation regarding the clustering of hunting blinds was substantiated by the results of this study.

The expectation stemming from Chapter III was that hunting landscapes, particularly hunting blinds, would be designed in a manner that maximizes the capabilities of the hunting technology. In other words, prehistoric hunting blinds would be spaced in accordance with the optimal performance of the bow and arrow. Utilizing ethnographic data pertaining to Native American archery, I determined that 18 meters represented the optimal shooting radius for a single archer. I then doubled this distance to 36 meters in order to represent numerous hunters shooting from opposite directions toward each other. The information gathered in the context of this study indicates that when practicing a collective hunting strategy and utilizing the bow and arrow hunting technology, the optimal spacing for hunting blinds would consist of a 36 meter radius. Thus, the second expectation derived from the research hypothesis was that prehistoric hunting blinds would be spaced, on average a distance of about 36 meters.

To examine this expectation I subjected the results of the hierarchical cluster to a series of nearest neighbor tests in order to ascertain the average distance to nearest neighbor. The results of the neighbor analysis indicated that the hunting blinds within each of the five clusters had an average distance to nearest neighbor that ranged from 31.49 to 37.39 meters (Table 3). These results are consistent with the expectation that hunting blinds are spaced according to the optimal performance characteristics of the bow and arrow. In short, the results of this study support the research hypothesis. Prehistoric hunting strategies were likely shaped by a forager’s drive to maximize their caloric intake, and foragers likely designed the hunting landscape to facilitate the optimal use of the bow and arrow.

Summary of this Study

The chapters of this thesis have shown how every behavior comes at the expense of time and energy. An argument has been made for the use of the optimality models within foraging theory as tools for assessing the costs and benefits associated with foraging behaviors.

This study has explored the theoretical tenets of evolutionary ecology, delved into the prehistory of Great Basin, and wrangled with complex computer-based analytical tools in effort to understand how collective hunting practices among the prehistoric foragers of the western Great Basin can be interpreted using the archaeological record. The primary issue dealt with in this thesis was one of space, specifically how foragers utilize space when pursuing for large game. The research hypothesis for this study contended that the use of space would reflect group size and hunting technology, and that these attributes could be seen in the archaeological manifestation of stone hunting blinds. Foraging theory and the models of optimality contained therein were drawn upon to generate expectations pertaining to foraging party group size, and the spatial placement of hunting blinds in relation to the performance characteristics of the bow and arrow technology.

The expectations were then tested using data from the Cowhead Slough archaeological survey. The geographic locations of 23 stone hunting blinds from Cowhead Slough were stored in a geographic information system. Then, using a geographic information system, a spider analysis was performed on the hunting blinds. Next, a hierarchical cluster analysis was conducted on he distances generated from the spider analysis. The cluster analysis arranged the 23 hunting blinds into five statistically derived clusters that were comprised of from three to seven hunting blinds each. Next, a nearest neighbor analysis was preformed on each cluster. The nearest neighbor analysis provided average distance to nearest neighbor for each of the clusters; these results were between 31.49 and 37.39 meters. The cluster and nearest neighbor results were then compared to the theoretical expectations developed for the clustering and spatial distribution of hunting blinds.

The results of this study demonstrate that hunting blinds within the Cowhead Basin occur in clusters consisting of from three and seven blinds. These statistically derived clusters support a collective hunting strategy for the capture of large game in the Cowhead Slough, and are consistent with expectations derived from foraging theory and the optimal group size model.

In addition, the results of the nearest neighbor preformed as part of this study have shown that within the hunting blind clusters, individual hunting blinds are spaced on average between 31.49 and 37.39 meters apart. This result is consistent with the expectation that hunting blinds would be spaced on average about 36 meters apart, in accordance with the optimal performance characteristics of the bow and arrow.

Conclusion

The data presented in this study has shown the models and theories contained within evolutionary ecology can aid archaeologists in interpreting the archaeological record of stone hunting features in the Great Basin. Not only do hunting blinds in the Cowhead Basin occur in groups consistent with the expectations derived from foraging theory and the optimal group size model, they also appear to be spaced in a manner consist with the optimal performance characteristics of the bow and arrow.

The optimal use of space and individuals when hunting likely produced a number of benefits to Great Basin foragers. Potential benefits could include a higher encounter rate, which in turn would trigger a decrease in pursuit time, thus increasing the maximization of caloric returns. This strategy could be employed to offset some of the energetic cost associated with a travel from a central place.

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APPENDIX A

SPIDER ANALYSIS DISTANCES

Feature of Origin	Destination Feature	Line Length	Org/Des ID
1	2	49.897884	12
1	3	85.626508	13
1	4	35.457844	14
1	5	159.873807	15
1	6	192.495790	16
1	7	209.589210	17
1	8	240.139524	18
1	9	313.732334	19
1	10	257.307415	110
1	11	230.135319	111
1	12	189.168320	112
1	13	446.671284	113
1	14	414.947318	114
1	15	363.265261	115
1	16	338.855049	116
1	17	315.826538	117
1	18	529.302594	118
1	19	568.975482	119
1	20	514.260495	120
1	21	214.998082	121
1	22	539.577265	122
1	25	195.947076	125
2	1	49.897884	21
2	3	36.182866	23
2	4	73.220513	24
2	5	120.235787	25
2	6	147.474059	26
2	7	164.301723	27
2	8	270.436555	28
2	9	349.871501	29
2	10	301.695126	210
2	11	253.924138	211

Feature of Origin	Destination Feature	Line Length	Org/Des ID
2	12	210.795847	212
2	13	494.256140	213
2	14	462.317694	214
2	15	411.669763	215
2	16	387.795894	216
2	17	364.691919	217
2	18	576.893303	218
2	19	611.974043	219
2	20	555.770867	220
2	21	264.857570	221
2	22	581.979919	222
2	25	245.298388	225
3	1	85.626508	31
3	2	36.182866	32
3	4	108.722575	34
3	5	104.437953	35
3	6	122.676479	36
3	7	138.640061	37
3	8	300.343685	38
3	9	381.985949	39
3	10	337.049019	310
3	11	280.871186	311
3	12	237.323905	312
3	13	530.326059	313
3	14	498.352373	314
3	15	447.844674	315
3	16	423.968405	316
3	17	400.868979	317
3	18	612.956735	318
3	19	646.600416	319
3	20	589.835954	320
3	21	300.565535	321
3	22	616.388237	322
3	25	281.390382	325
4	1	35.457844	41
4	2	73.220513	42
4	3	108.722575	43
4	5	161.060094	45
4	6	198.759999	46

Feature of Origin	Destination Feature	Line Length	Org/Des ID
4	7	215.805886	47
4	8	204.883789	48
4	9	279.859152	49
4	10	228.479873	410
4	11	194.779569	411
4	12	154.144614	412
4	13	422.070618	413
4	14	389.987937	414
4	15	340.501870	415
4	16	317.648327	416
4	17	294.444047	417
4	18	504.658293	418
4	19	538.932003	419
4	20	483.129815	420
4	21	199.855523	421
4	22	509.073562	422
4	25	177.084055	425
5	1	159.873807	51
5	2	120.235787	52
5	3	104.437953	53
5	4	161.060094	54
5	6	43.583985	56
5	7	58.715239	57
5	8	291.303880	58
5	9	380.078562	59
5	10	362.507270	510
5	11	260.247201	511
5	12	219.597796	512
5	13	562.874349	513
5	14	530.416810	514
5	15	487.234542	515
5	16	467.796372	516
5	17	444.729834	517
5	18	644.068575	518
5	19	656.502349	519
5	20	595.668893	520
5	21	358.788760	521
5	22	624.725622	522
5	25	333.441587	525

Feature of Origin	Destination Feature	Line Length	Org/Des ID
6	1	192.495790	61
6	2	147.474059	62
6	3	122.676479	63
6	4	198.759999	64
6	5	43.583985	65
6	7	17.134740	67
6	8	334.418739	68
6	9	423.334781	69
6	10	405.709985	610
6	11	302.635162	611
6	12	262.542554	612
6	13	605.956755	613
6	14	573.496050	614
6	15	529.676852	615
6	16	509.733789	616
6	17	486.607022	617
6	18	687.297269	618
6	19	699.973295	619
6	20	639.028424	620
6	21	398.154534	621
6	22	668.161473	622
6	25	373.741387	625
7	1	209.589210	71
7	2	164.301723	72
7	3	138.640061	73
7	4	215.805886	74
7	5	58.715239	75
7	6	17.134740	76
7	8	347.583064	78
7	9	436.684633	79
7	10	421.213363	710
7	11	314.915228	711
7	12	275.541677	712
7	13	621.589527	713
7	14	589.132038	714
7	15	545.781144	715
7	16	526.077585	716
7	17	502.973273	717
7	18	702.764068	718

Feature of Origin	Destination Feature	Line Length	Org/Des ID
7	19	713.753590	719
7	20	652.525858	720
7	21	415.093785	721
7	22	681.844015	722
7	25	390.529422	725
8	1	240.139524	81
8	2	270.436555	82
8	3	300.343685	83
8	4	204.883789	84
8	5	291.303880	85
8	6	334.418739	86
8	7	347.583064	87
8	9	89.257935	89
8	10	119.781515	810
8	11	40.800022	811
8	12	72.112643	812
8	13	299.815275	813
8	14	269.191280	814
8	15	245.848499	815
8	16	240.335514	816
8	17	222.488119	817
8	18	374.234176	818
8	19	366.998286	819
8	20	305.142024	820
8	21	210.336182	821
8	22	334.837857	822
8	25	180.913411	825
9	1	313.732334	91
9	2	349.871501	92
9	3	381.985949	93
9	4	279.859152	94
9	5	380.078562	95
9	6	423.334781	96
9	7	436.684633	97
9	8	89.257935	98
9	10	101.314731	910
9	11	126.011269	911
9	12	161.356271	912
9	13	225.685693	913

Feature of Origin	Destination Feature	Line Length	Org/Des ID
9	14	198.008972	914
9	15	190.784908	915
9	16	195.623897	916
9	17	184.553409	917
9	18	293.841880	918
9	19	277.793226	919
9	20	215.901984	920
9	21	218.779009	921
9	22	245.595292	922
9	25	197.025402	925
10	1	257.307415	101
10	2	301.695126	102
10	3	337.049019	103
10	4	228.479873	104
10	5	362.507270	105
10	6	405.709985	106
10	7	421.213363	107
10	8	119.781515	108
10	9	101.314731	109
10	11	157.758485	1011
10	12	169.992478	1012
10	13	200.523442	1013
10	14	168.102668	1014
10	15	131.514234	1015
10	16	121.645771	1016
10	17	102.836166	1017
10	18	281.588271	1018
10	19	311.990002	1019
10	20	259.398764	1020
10	21	118.141296	1021
10	22	283.219193	1022
10	25	99.573007	1025
11	1	230.135319	111
11	2	253.924138	112
11	3	280.871186	113
11	4	194.779569	114
11	5	260.247201	115
11	6	302.635162	116
11	7	314.915228	117

Feature of Origin	Destination Feature	Line Length	Org/Des ID
11	8	40.800022	118
11	9	126.011269	119
11	10	157.758485	1110
11	12	43.594639	1112
11	13	340.589221	1113
11	14	309.991301	1114
11	15	285.853191	1115
11	16	279.174820	1116
11	17	260.544597	1117
11	18	414.645502	1118
11	19	403.098360	1119
11	20	340.462548	1120
11	21	237.431374	1121
11	22	370.724733	1122
11	25	206.656987	1125
12	1	189.168320	121
12	2	210.795847	122
12	3	237.323905	123
12	4	154.144614	124
12	5	219.597796	125
12	6	262.542554	126
12	7	275.541677	127
12	8	72.112643	128
12	9	161.356271	129
12	10	169.992478	1210
12	11	43.594639	1211
12	13	363.906276	1213
12	14	332.299245	1214
12	15	301.402976	1215
12	16	290.559828	1216
12	17	270.021817	1217
12	18	441.028534	1218
12	19	439.013961	1219
12	20	377.251785	1220
12	21	228.348257	1221
12	22	406.896470	1222
12	25	196.846964	1225
13	1	446.671284	131
13	2	494.256140	132

Feature of Origin	Destination Feature	Line Length	Org/Des ID
13	3	530.326059	133
13	4	422.070618	134
13	5	562.874349	135
13	6	605.956755	136
13	7	621.589527	137
13	8	299.815275	138
13	9	225.685693	139
13	10	200.523442	1310
13	11	340.589221	1311
13	12	363.906276	1312
13	14	32.460812	1314
13	15	86.906940	1315
13	16	116.282313	1316
13	17	136.424210	1317
13	18	82.643436	1318
13	19	169.014360	1319
13	20	155.227246	1320
13	21	247.130618	1321
13	22	156.433279	1322
13	25	254.937012	1325
14	1	414.947318	141
14	2	462.317694	142
14	3	498.352373	143
14	4	389.987937	144
14	5	530.416810	145
14	6	573.496050	146
14	7	589.132038	147
14	8	269.191280	148
14	9	198.008972	149
14	10	168.102668	1410
14	11	309.991301	1411
14	12	332.299245	1412
14	13	32.460812	1413
14	15	59.624759	1415
14	16	89.946119	1416
14	17	108.043424	1417
14	18	114.697263	1418
14	19	186.254751	1419
14	20	161.521329	1420

Feature of Origin	Destination Feature	Line Length	Org/Des ID
14	21	218.312990	1421
14	22	168.772467	1422
14	25	224.420503	1425
15	1	363.265261	151
15	2	411.669763	152
15	3	447.844674	153
15	4	340.501870	154
15	5	487.234542	155
15	6	529.676852	156
15	7	545.781144	157
15	8	245.848499	158
15	9	190.784908	159
15	10	131.514234	1510
15	11	285.853191	1511
15	12	301.402976	1512
15	13	86.906940	1513
15	14	59.624759	1514
15	16	30.345730	1516
15	17	49.548121	1517
15	18	167.954577	1518
15	19	244.702431	1519
15	20	214.167741	1520
15	21	160.237842	1521
15	22	225.174941	1522
15	25	169.247199	1525
16	1	338.855049	161
16	2	387.795894	162
16	3	423.968405	163
16	4	317.648327	164
16	5	467.796372	165
16	6	509.733789	166
16	7	526.077585	167
16	8	240.335514	168
16	9	195.623897	169
16	10	121.645771	1610
16	11	279.174820	1611
16	12	290.559828	1612
16	13	116.282313	1613
16	14	89.946119	1614

Feature of Origin	Destination Feature	Line Length	Org/Des ID
16	15	30.345730	1615
16	17	23.222589	1617
16	18	195.967468	1618
16	19	274.840569	1619
16	20	242.713741	1620
16	21	131.739705	1621
16	22	254.784674	1622
16	25	143.360023	1625
17	1	315.826538	171
17	2	364.691919	172
17	3	400.868979	173
17	4	294.444047	174
17	5	444.729834	175
17	6	486.607022	176
17	7	502.973273	177
17	8	222.488119	178
17	9	184.553409	179
17	10	102.836166	1710
17	11	260.544597	1711
17	12	270.021817	1712
17	13	136.424210	1713
17	14	108.043424	1714
17	15	49.548121	1715
17	16	23.222589	1716
17	18	217.348969	1718
17	19	289.889640	1719
17	20	253.865546	1720
17	21	110.706758	1721
17	22	268.149016	1722
17	25	120.610587	1725
18	1	529.302594	181
18	2	576.893303	182
18	3	612.956735	183
18	4	504.658293	184
18	5	644.068575	185
18	6	687.297269	186
18	7	702.764068	187
18	8	374.234176	188
18	9	293.841880	189

Feature of Origin	Destination Feature	Line Length	Org/Des ID
18	10	281.588271	1810
18	11	414.645502	1811
18	12	441.028534	1812
18	13	82.643436	1813
18	14	114.697263	1814
18	15	167.954577	1815
18	16	195.967468	1816
18	17	217.348969	1817
18	19	134.552252	1819
18	20	154.354320	1820
18	21	327.683235	1821
18	22	138.927464	1822
18	25	336.982456	1825
19	1	568.975482	191
19	2	611.974043	192
19	3	646.600416	193
19	4	538.932003	194
19	5	656.502349	195
19	6	699.973295	196
19	7	713.753590	197
19	8	366.998286	198
19	9	277.793226	199
19	10	311.990002	1910
19	11	403.098360	1911
19	12	439.013961	1912
19	13	169.014360	1913
19	14	186.254751	1914
19	15	244.702431	1915
19	16	274.840569	1916
19	17	289.889640	1917
19	18	134.552252	1918
19	20	63.806910	1920
19	21	395.581019	1921
19	22	32.535516	1922
19	25	394.628259	1925
20	1	514.260495	201
20	2	555.770867	202
20	3	589.835954	203
20	4	483.129815	204

Feature of Origin	Destination Feature	Line Length	Org/Des ID
20	5	595.668893	205
20	6	639.028424	206
20	7	652.525858	207
20	8	305.142024	208
20	9	215.901984	209
20	10	259.398764	2010
20	11	340.462548	2011
20	12	377.251785	2012
20	13	155.227246	2013
20	14	161.521329	2014
20	15	214.167741	2015
20	16	242.713741	2016
20	17	253.865546	2017
20	18	154.354320	2018
20	19	63.806910	2019
20	21	353.060652	2021
20	22	31.485439	2022
20	25	348.252342	2025
21	1	214.998082	211
21	2	264.857570	212
21	3	300.565535	213
21	4	199.855523	214
21	5	358.788760	215
21	6	398.154534	216
21	7	415.093785	217
21	8	210.336182	218
21	9	218.779009	219
21	10	118.141296	2110
21	11	237.431374	2111
21	12	228.348257	2112
21	13	247.130618	2113
21	14	218.312990	2114
21	15	160.237842	2115
21	16	131.739705	2116
21	17	110.706758	2117
21	18	327.683235	2118
21	19	395.581019	2119
21	20	353.060652	2120
21	22	371.268348	2122

Feature of Origin	Destination Feature	Line Length	Org/Des ID
21	25	31.507218	2125
22	1	539.577265	221
22	2	581.979919	222
22	3	616.388237	223
22	4	509.073562	224
22	5	624.725622	225
22	6	668.161473	226
22	7	681.844015	227
22	8	334.837857	228
22	9	245.595292	229
22	10	283.219193	2210
22	11	370.724733	2211
22	12	406.896470	2212
22	13	156.433279	2213
22	14	168.772467	2214
22	15	225.174941	2215
22	16	254.784674	2216
22	17	268.149016	2217
22	18	138.927464	2218
22	19	32.535516	2219
22	20	31.485439	2220
22	21	371.268348	2221
22	25	368.620509	2225
25	1	195.947076	251
25	2	245.298388	252
25	3	281.390382	253
25	4	177.084055	254
25	5	333.441587	255
25	6	373.741387	256
25	7	390.529422	257
25	8	180.913411	258
25	9	197.025402	259
25	10	99.573007	2510
25	11	206.656987	2511
25	12	196.846964	2512
25	13	254.937012	2513
25	14	224.420503	2514
25	15	169.247199	2515
25	16	143.360023	2516

Feature of Origin	Destination Feature	Line Length	Org/Des ID
25	17	120.610587	2517
25	18	336.982456	2518
25	19	394.628259	2519
25	20	348.252342	2520
25	21	31.507218	2521
25	22	368.620509	2522