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OPTIMAL FORAGING AND POPULATION DYNAMICS: AN ARCHAEOLOGICAL  
INVESTIGATION AT THE BIRCH CREEK ROCKSHELTERS, IDAHO

by

Samuel H. M. Yeates

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

of

MASTER OF SCIENCE

in

Archeology and Cultural Resource Management

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2019

## ABSTRACT

Optimal Foraging and Population Dynamics: An Archaeological Investigation at the  
Birch Creek Rockshelters, Idaho

by

Samuel H. M. Yeates, Master of Science

Utah State University, 2019

Major Professor: Dr. David A. Byers  
Department: Sociology, Social Work, and Anthropology

This thesis aims to integrate the study of population dynamics with the expectations of the optimal foraging models, and to test whether expectations resulting from integrating these two bodies of theory have greater predictive power than the prey model alone. To compare these models, I monitored prey age, processing intensity, and prey rank in five prehistoric occupations of the Birch Creek rockshelters of Idaho. I modeled hunting pressure (top-down abundance limitation) with a summed probability distribution of radiocarbon dates from Idaho archaeological sites, and modeled carrying capacity (bottom-up abundance limitation) with an archaeoclimate model of effective moisture. Both models predicted lower prey age, lower average prey rank, and greater processing intensity when human hunting pressure is high and when prey carrying capacity is low. However, unlike the prey model the Forager-resource Population Ecology (FPE) model predicts that similarly-ranked taxa with different rates of intrinsic increase should show different degrees of resilience to top-down abundance limitation. Contrary to FPE model predictions, statistical analyses of the Birch Creek archaeofauna did not detect a greater top-down limitation effect on taxa with slower rates of intrinsic

increase than on faster increasing taxa of a similar rank. While the Birch Creek archaeofauna provided a limited and flawed dataset, my results did not support the use of the FPE model.

(215 pages)

## PUBLIC ABSTRACT

Optimal Foraging and Population Dynamics: An Archaeological Investigation at the  
Birch Creek Rockshelters, Idaho

Samuel H. M. Yeates

This thesis aims to integrate the study of population change with the expectations of foraging models, and to test whether expectations resulting from integrating these two bodies of theory have greater predictive power than foraging models alone. To compare these models, I monitored prey age, butchery practice, and prey desirability in five prehistoric occupations of the Birch Creek rockshelters of Idaho. I modeled hunting pressure with a human population density estimate based on radiocarbon dates from Idaho archaeological sites, and modeled prey abundance with a model of historic effective moisture. Both models predicted younger prey, lower average prey desirability, and more intensive extraction of nutrients from prey when human hunting pressure is high and when prey are scarce. However, unlike the prey model, the Forager-resource Population Ecology (FPE) model predicts that similarly desirable prey with different reproductive rates should show different degrees of resilience to hunting pressure. Contrary to FPE model predictions, statistical analyses of the Birch Creek faunal materials did not indicate that human hunting pressure disproportionately stressed populations of slowly reproducing prey compared to quicker-reproducing prey. While the faunal specimens from Birch Creek provided a limited and flawed dataset, my results did not support the use of the FPE model.

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Samuel H. M. Yeates

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## INTRODUCTION

My thesis fulfils two goals: first, I intend to integrate the study of prey population dynamics (Euler 1760; Fisher 1930; Lotka 1925; Malthus 1798; Nicholson 1933; Verhulst 1838) with the prey model (Stephens and Krebs 1986) so frequently used in optimal foraging theory. Second, I test whether the expectations resulting from integrating these two bodies of theory can be detected within the archaeological record. By integrating the study of prey choice with prey population dynamics, archaeologists should be able to better describe the effects of foraging-based subsistence strategies. When archaeologists and paleoecologists can better quantify the effects of foraging populations upon prey populations, they will both be able to better model non-agricultural populations as drivers of environmental change.

Archaeologists often use optimal foraging models to explain the behaviors that lead to the creation of archaeofaunal assemblages (Broughton 1994, 1999, 2002; Broughton et al 2011; Byers et al. 2005; Byers and Broughton 2004; Nagaoka 2002a, 2002b; Smith et al. 2008; Tushingham and Bettinger 2013). The diet breadth, or prey choice model (Stephens and Krebs 1986), in particular, is the most common optimal foraging model used to explain diverse subsistence practices, observable from changes in the fauna recovered from archaeological sites over space and time (Bayham 1979; Broughton 1994; 1999, 2002; Broughton and Bayham 2003; Broughton et al. 2011; Byers and Broughton 2004; Byers et al. 2005; Elston and Zeanah 2002; Hawkes 1991; Nagaoka 2002a, 2002b; Smith et al. 2008; Stiner and Munro 2002). Importantly, however, the prey choice model stops short of considering prey population dynamics when predicting the consequences of foraging decisions for prey populations.

The prey choice model predicts the number of prey species in a foragers diet (their diet breadth) as a function of prey quality and abundance. In the standard prey choice model (MacArthur and Wilson 1966), prey quality and abundance are treated as parameters that change much more slowly than decisions about prey choice. These assumptions ignore the effects of game population ecology on foraging behavior (Winterhalder and Lu 1997). This is potentially important because game species' different vulnerabilities to predation could have different consequences for human hunting pressure. While some studies (Broughton 1994, 1999; Nagaoka 2002) address the effects of prey choice on the depression, and eventual extirpation or extinction of high-ranked game, they do not operationalize the possible effects of game reproductive rates on this phenomenon. As such, the prey choice model does not predict different *consequences* of human prey choice for prey with different population dynamics. My thesis evaluates whether the inclusion of game population dynamics within a modified diet breadth model better explains patterns in a zooarchaeological assemblage than does the standard prey choice model.

The study of population dynamics allows ecologists to operationalize changes in species abundance over time and, in some cases, space (Euler 19760; Fisher 1930; Holling 1973; Lotka 1925; Malthus 1978; Nicholson 1933; Verhulst 1838; Volterra 1928). Population dynamics can be modeled multiple ways. Density dependent models such as the Verhulst-Pearl Logistic Equation (Pearl and Reed 1920; Verhulst 1838) are a common way to model a population's dynamics with a density dependent logistic growth function. Within density dependent population growth models, two parameters control populations:  $r$ , which defines the intrinsic rate at which a given population increases,



(Pearl and Reed 1920; Verhulst 1838) and  $K$ , which defines the growth limiting effects of competition on population growth. More sophisticated models can account for immigration, emigration, resource competition, and the age profiles of modeled populations. Moreover, the phenomena simulated by density dependent population modeling have consequences for the study of archaeofaunas.

I use the faunal assemblage from Birch Creek (Swanson 1972), in conjunction with paleoclimatic data, to test the predictions of two versions of the prey model: the standard version of the prey model (MacArthur and Wilson 1966) and an extended version that includes the population growth dynamics of prey species, the Forager-resource Population Ecology model (FPE) (Winterhalder and Lu 1997). A more nuanced appreciation for the interaction between human populations and their food resources should allow for better planning and management of rising population density and changing demographics in the future. Furthermore, my work with the Birch Creek faunal remains has substantively improved the collection's documentation and made the site more useful for future research.

## **Research Design**

I expect the FPE model to more completely describe predator-prey interactions than does the prey choice model alone. Perhaps more to the point, I expect that, rank being held equal, species with slower rates of intrinsic increase are more vulnerable to hunting pressure than species with relatively quick rates of intrinsic increase. I expect to see patterns in element use, human responses to environmental effects, and prey response to human population pressure within Birch Creek's faunal assemblage; all these patterns

should be more consistent with the FPE model's predictions than with the prey model's predictions. As the FPE model considers prey with rapid rates of intrinsic increase ( $r$ ) as less vulnerable to hunting pressure than low  $r$  prey, I expect large human populations to correspond to a higher proportional representation of high  $r$  prey. I also expect that processing intensity should increase as the proportion of low rank prey in the diet increases, whereas increases in the proportionate abundance of medium rank prey should not reduce foraging efficiency enough to justify increased processing effort. Finally, I expect changing climatic conditions to influence the availability of prey on the landscape. While this expectation does not provide a means with which to test the appropriateness of the FPE model as opposed to the prey model, controlling for associated variables proved necessary to avoid mistaking the effects of environmental change for the effects of human behavior.

I have collected primary data from the Birch Creek archaeofauna and used this data to calculate secondary data. Data from Birch Creek inform on dietary composition, processing intensity, and taphonomy at Birch Creek. Ecological data obtained from literature review include climatic and floral community reconstruction, as well as a human population density estimate derived from a summed probability distribution of previously reported radiocarbon dates.

### **Archaeological Data**

All primary data used here derive from my analysis of the Birch Creek archaeofauna. Birch Creek, a high mountain valley just north of Idaho's Snake River Plain and southwest of the Beaverhead Mountains, contains two notable rockshelters,

Bison and Veratic (Swanson 1972). These rockshelters produced abundant artifacts and zooarchaeological remains (Swanson 1972). The youngest radiocarbon date collected from the site dates to  $410 \pm 125$  cal yr BP, and the oldest is  $11,690 \pm 2095$  cal yr BP (Table 4.5; Reimer et al. 2013). These sites' deep stratigraphy, extensive faunal remains (approximately 3,800 specimens), and occupational history should permit investigation into the long-term patterns of subsistence behavior that the FPE model attempts to describe.

Veratic (10CL3) and Bison Rockshelters (10CL10) contain rich, stratified sequences of zooarchaeological remains (Swanson 1972). These materials include, in general order of commonality, bison (*Bison bison*), bighorn sheep (*Ovis canadensis*), deer (presumably mule deer (*Odocoileus hemionus*) though they are only identified to the genus level), pronghorn (*Antilocapra americanus*), lagomorphs (genera *Sylvilagus* and *Lepus*), and elk (*Cervus canadensis*) (Swanson 1972). Sage grouse (*Centrocercus urophasianus*), while also present, only appear within a limited provenience at Veratic Rockshelter, where they are common.

In order to test my model, I have recorded the Birch Creek's archaeofauna according to the classification scheme used by Todd (1987) to quantify the animal remains recovered from the Horner II bone bed. Additionally, I report the scan sites present on each element as described by Lyman's (1994) *Vertebrate Taphonomy*. Jointly, these recording methods allowed me to quantify the prey present at Birch Creek, the intensity with which site inhabitants processed prey, and any taphonomic changes wrought upon the assemblage by carnivores and *in situ* destruction.

## Ecological Data

I also collected secondary data on climate and population density. I use previously reported radiocarbon dates as a proxy for population density, and a centennial-scale archaeoclimate model (Bryson and Bryson 2000) based on data from the Burley, Idaho NOAA reporting station. I supplement this climatic data with information from the Snake River Plain (and surrounding area) pollen record (Beck and Jones 1997; Beiswenger 1991; Bright 1966; Davis et al 1986; Doner 2009; Plager and Holmer 2004). I use Bailey's (1958) modified Thornthwaite moisture index (1948) to plot effective precipitation against the time span of Birch Creek's habitation.

To test my prediction that the Snake River Plain's eras of high population density correspond with diets dominated by high  $r$  game, I first amassed a large collection of radiocarbon dates from sites on the Snake River Plain. I assume that the cultural generation of carbon correlates positively with human population abundance (Kelly et al. 2013). This approach, well established in archaeology (Kelly et al. 2013; Rick 1987; Shennan et al. 2013), considers radiocarbon dates as data. I use the Snake River Plain's radiocarbon data to create a summed probability distribution of radiocarbon dates in Calib 7.1 (Stuiver 2018) over the course of the Snake River Plain's prehistoric occupation. These data came from a dataset compiled by Byers (personal communication), and are available in Appendix A. I average the probability values from each phase to create values for each phase that I plot against relevant variables from the Birch Creek archaeofauna.

## **Thesis Organization**

Evaluating the way that prey population dynamics may have influenced resource depression requires several tasks. Chapter 2, Theoretical Background and Expectations, provides background information on the central body of theory important to my thesis. Chapter 2 includes a section on Behavioral Ecology, particularly focusing on the Optimal Foraging Theory relevant to my project. This chapter also includes a discussion of the ecology of the prey species present at Birch Creek. Next, Chapter 2 lays out the general implications of the FPE model for human behavior. Lastly, I lay out criteria for testing the model's implications.

Chapter 3, Methods, outlines my primary data collection methods and my secondary data generation methods. I introduce the concept of taphonomy, and my attempts to account for taphonomic processes. My primary data collection methods attempt to quantify the fauna represented at Birch Creek and to document modification to the remains. My secondary data generation efforts focus on creating indices for processing intensity, prey mortality profiles, site and regional population density, and net acquisition rate.

Chapter 4, Independent Variables, details the variables that I expect to either influence prey abundance in their own right, or mediate the effects of harvest pressure on prey abundance. These variables include the reproductive rates of prey species, regional human population density, and variation in the regional climate. I report trends in these variables and predict outcomes for the archaeological record that are consistent with the

FPE model. Finally, I identify a list of characteristics needed in a dataset to test my predictions.

In Chapter 5, Investigations at Birch Creek, I describe the Birch Creek archaeofauna's context. This includes the physical setting of the rockshelters and Swanson's prior work. My description of Swanson's work details his excavation program, organizational scheme, and his cataloging efforts. I summarize Swanson's data, and report his findings in tabular form. Finally, I identify failings in the Birch Creek faunal assemblage, and the implications of these failings for my study. While describing Swanson's work, I explain the organizational basis that I use to test my hypotheses.

In Chapter 6, Results, I present the results of my cataloging efforts and of my secondary data generation. I present these findings in tabular and graphical form and outline trends in the faunal material within the Birch Creek assemblage. I next use my primary and secondary datasets to test the expectations outlined in detail within Chapter 4. I also comment on differences in the results of my cataloging efforts and Swanson's reported data.

In Chapter 7, Discussion and Conclusion, I cover the results of the tests I perform in Chapter 6. I discuss whether the FPE model's predictions are valid and whether the Birch Creek data set proved adequate to evaluate the model. I also explore other mechanisms that could result in the conditions of the Birch Creek archaeofauna. By exploring these mechanisms, I attempt to deal with the problem of equifinality. Finally, I evaluate whether the FPE model proved worthy of wider application to other parts of the archaeological record.

## THEORETICAL BACKGROUND

In this chapter, I cover the theory informing my analysis of the Birch Creek archaeofauna. Specifically, I employ theory developed to quantify both forager decision making and prey population dynamics. The first body of theory on decision making provides insight into the desirability of different prey types, which should allow me to describe human foraging behavior. The second body of theory on prey population dynamics helps create expectations for the outcomes of foraging decisions on the accumulation of faunal assemblages in the archaeological record.

Evolutionary Ecology, particularly its subfield Human Behavioral Ecology (HBE), provides the tools to achieve my goals. Specifically, I focus on the use of a set of foraging models drawn from HBE. These together comprise Optimal Foraging Theory (OFT), which describes the decision making of foragers under various socioecological conditions. I also cover the use of the logistic model to describe population growth. Once I cover the theory, I discuss the Forager-resources Population Ecology (FPE) model, which integrates the expected outcomes of foraging behavior, as predicted by one optimal foraging model (prey choice), with the population ecology dynamics quantified by logistic modeling (Winterhalder and Lu 1997). This last point is important as the effects of prey population ecology on prey choice remain understudied (Stiner and Munro 2002) and represent an important gap in knowledge that my thesis addresses. Finally, I discuss the implications of the FPE model for my thesis.

## **Evolutionary Ecology, Human Behavioral Ecology**

Evolutionary ecology (EE) can be defined as the application of the theory of evolution via natural selection to the study of adaptation and biological design in an ecological setting (Winterhalder and Smith 1992). Thus, EE examines the interactions between evolutionary forces and ecological variables to understand adaptive design in behavior, life history, and morphology (Hutchinson 1965). EE, as an evolutionary science, defines as adaptive those traits that increase the fitness of an organism relative to alternative traits in a given socioecological context (Broughton and Cannon 2010). Fitness is defined as an individual's ability to survive and replicate its genes via reproductively viable offspring (Smith 1983; Broughton and Cannon 2010).

Behavioral ecology is the subfield of EE that attempts to explain behavioral variability (Broughton and O'Connell 1999; Krebs and Davies 1978, 1984, 1991, 1997). Rather than studying inheritance, behavioral ecology sees behavior as the plastic phenotypic result of selection pressure for decision rules (Grafen 1984; Smith and Winterhalder 1992; Shennan 2002). While behaviors can themselves enhance or reduce fitness, genotype determines the ability of an organism to select an adaptive behavior for a given situation from the suite of all behaviors that it can execute. Human behavioral ecology is the application of behavioral ecology's principles to human populations (Borgerhoff Mulder 1991; Cronk 1991; Smith 1992; Smith and Winterhalder 1992; Winterhalder and Smith 2000).

Human behavioral ecology makes extensive use of models, both formal and informal, to evaluate questions concerning the fitness of alternative behaviors in a given



socioecological context (Broughton and O'Connell 1999; Kaplan and Hill 1992; Stephens and Krebs 1986). These models allow researchers to create baseline expectations about which behaviors should be expected from organisms operating within specific ecological constraints. By testing the expectations of such models, researchers can answer specific questions about behaviors and the results of such behaviors on the archaeological record.

### Optimal Foraging Theory

OFT consists of a set of formal models that assume that organisms whose behaviors are closer to the optimal strategy for procuring fitness-enhancing currencies, such as calories, will have greater fitness than those organisms that choose less optimal strategies (Alexander 1974, Irons 1979). This assumption requires no conscious decision making, but merely assumes fitness enhancing outcomes for any individual that stumbles upon a closer to optimal strategy. Intentionality or “intelligence” as popularly conceived do not necessarily enter into optimality except insofar as these traits *may* lead to closer to optimal behavior (Maynard Smith 1978; Smith and Winterhalder 1992; Stearns 1977).

The foraging strategy capable of satisfying an organism's metabolic needs (maintenance and reproductive) with a minimum of cost (caloric, time, and risk exposure) can be considered optimal (Kaplan and Hill 1992). This definition flows from the assumption that one or more of three conditions for the organism under study prove true. The first condition is that a greater total caloric acquisition results in greater reproductive success or survival (Smith 1983). This greater caloric intake may mean better provisioning of offspring, greater birthweights, larger forager body size, and other possible proxies for wellbeing. The next possible condition is met when reduced

foraging effort allows an organism to devote more effort to other fitness-enhancing behaviors. Such behaviors include mating effort in its myriad forms, and may include investment in technologies, such as shelter building, which, although not related to caloric acquisition, nevertheless improve individual or familial survivorship. The final condition is met when foraging entails exposure to otherwise avoidable hazards, such as predators, ailments, or other environmental conditions that may result in loss of life or reproductive viability (Orians 1971; Schoener 1971; Smith 1979; Winterhalder 1981, 1983). Optimal foraging models allow behavioral ecologists to quantify foraging strategies and identify the optimal strategy given a set of constraints on viable strategies (Kaplan and Hill 1992).

The creation of a foraging model involves making assumptions about the constraints, currency, and decision that comprise the basic components of a foraging model (Stephens and Krebs 1986). The decision assumption outlines the choice that the model attempts to describe. The currency assumption describes the basis for the evaluation of the merits of each choice. Constraint assumptions delimit feasible choices and limitations to possible pay-offs from the modeled question (Stephens and Krebs 1986).

In this thesis, I use the prey choice model (Emlen 1966; MacArthur and Pianka 1966; Charnov and Orians 1973; Charnov 1976; Schoener 1971; Stephens and Krebs 1986). This model describes the decision to take or ignore a prey item upon encounter. Foraging efficiency, most often measured in calories obtained per hour spent foraging (return rate), represents the currency of the prey model. Application of the prey model requires consideration of a number of other constraints as well. The prey model assumes

a homogeneous, well mixed distribution of prey, hunters with perfect knowledge of prey encounter rates and quality, sequentially encountered prey, mutually exclusive searching and handling, “free” encounters without pursuit, and prey possessing characteristics, which are inherent, rather than functions of the pursuit decision. Importantly, the prey choice model makes no assumptions about prey population dynamics. This is ignored because in most ecological applications of the model, foraging decisions are made at time-scales where prey population dynamics will not affect decision-making (e.g., birds foraging in lab experiments). However, the archaeological record is an amalgam of refuse accumulated over time. In this context, prey population dynamics may affect the decisions of human foragers (Stiner and Munro 2002; Winterhalder and Lu 1997).

The prey model measures total return rate as the result of search costs and post-encounter return rate. Thus, total return rate is calculated by dividing the calories yielded by all taken prey, by the combined time spent searching for and handling (pursuing, killing, and processing) that prey (Broughton and Cannon 2010; Stephens and Krebs 1986). Hunters weigh the foraging efficiency that results from taking an encountered animal against the foraging efficiency possible by continuing to hunt for higher quality prey.

Post-encounter caloric return rate determines prey quality, or rank.

Archaeologists often use body size as a proxy for prey rank, because large bodied animals tend to have greater post-encounter returns (Broughton et al. 2011; Ugan 2005), and because ethnographic records demonstrate that male hunters nearly always pursue the largest game on the landscape (Hawkes 1991, 1993; Wiessner 2002). As the highest-ranked prey yield the highest post-encounter return rates, hunters always pursue these

items when encountered. In contrast, the prey model predicts the pursuit of lower-ranked prey only when high-ranked prey encounter rates are low enough that the inclusion of lower ranked prey increases net acquisition rate (NAR) (Bayham 1979). Archaeologists can thus use an archaeofaunal assemblage to gauge the relative foraging efficiency of a site's inhabitants.

The archaeological implications of the prey model are well-developed (Broughton 1994, 1999, 2002; Broughton et al 2011; Byers and Broughton 2004; Byers et al. 2005; Nagaoka 2002a, 2002b; Smith et al. 2008). Generally, the largest species in an assemblage/provenience can be considered the highest ranked available prey (Broughton et al. 2011; Hawkes 1991, 1993; Ugan 2005; Wiessner 2002). The inclusion of smaller-bodied animals typically indicates a situation where foraging returns were low enough to warrant the inclusion of less profitable prey.

Archaeological assemblages violate a number of prey model assumptions. Perhaps most obviously, most archaeological sites represent accumulations from a number of individuals, if not a number of generations. Archaeologists must therefore use a model intended to describe the decision-making behavior of an average individual to analyze the outcome of the behavior of multiple communities over centuries. In many cases, the sexual division of labor and other societal subdivisions mean that archaeological faunal assemblages result from multiple individuals making choices with effectively different encounter rates (Elston and Zeanah 2002; Hawkes 1991, 1993; Wiessner 2002; Zeanah 2004). Furthermore, archaeological assemblages often span differing environmental conditions in which encounter rates can fluctuate. While a number of researchers have addressed these problems (Broughton 2002; Byers and

Broughton 2004; Nagoaka 2002a, 2002b), one issue, namely the effects of prey population ecology on prey choice, remain understudied (but see Stiner and Munro 2002), and represent an important gap in knowledge that my thesis addresses. While the FPE model provides insight into the consequences of prey choice for both forager and prey populations, it adheres to the predictions made by the prey choice model for prey ranking and is used as such throughout my thesis.

### **Density Dependent Population Dynamics**

Malthus (1798) first described the growth dynamics of populations, specifically human populations. He posited exponential population growth as a result of an increasing number of reproductive individuals. He further predicted tragedy when the earth's finite resources became insufficient to feed a population that grows at an ever-increasing rate. Verhulst (1838) operationalized Malthus's principles and developed a logistic growth model that both accounted for an increasing rate of population growth driven by increasingly abundant reproductive individuals, and a reduction in growth from a commensurate degree of competition for finite resources. Pearl and Reed (1920) brought Verhulst's model back into widespread usage as the Verhulst-Pearl Logistic Growth Model.

The Verhulst-Pearl Logistic Growth Model (Pearl and Reed 1920; Verhulst 1838) represents one way to describe population dynamics. This model represents population growth with a density dependent growth function. Density dependence means that population density affects population growth. In the case of the logistic model, as

population approaches the carrying capacity,  $K$ , of a finite territory, competition for resources limits population growth. When depicted graphically, this function plots a curve tracking population growth against total population. Density dependent logistic functions use the parameters  $r$  and  $K$  and the variable  $N$  to describe intrinsic population growth, as in the equation:

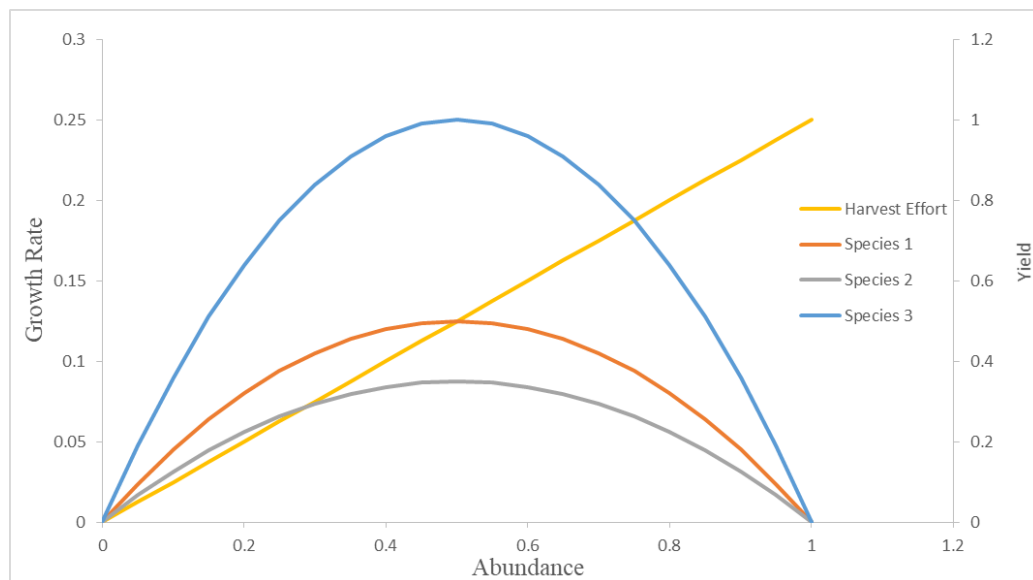
$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right).$$

In this formula,  $N$  stands for the population at time  $t$ ,  $K$  represents carrying capacity, and  $r$  is the proportional increase in a population prior to modification by the effects of carrying capacity. A population's growth peaks when the  $N$  is at half of  $K$ , as this represents the maximum number of breeding individuals possible on the landscape before competition over resources begins to reduce effective fertility. Figure 2.1 illustrates this dynamic.

Different species, including similarly ranked species often have significantly different  $r$ -values (Calef 1984; Caughley 1977; Cole 1954; Eberhardt 1987; Gogan and Barrett 1987; Hatter and Janz 1994; Hennemann 1983; Hodges et al. 2001; Houston 1982; Larter et al. 1994; McCorquodale et al.; MacLulich 1937; Singer and Norland 1994; Wooster 1935). Variance in  $r$  reflects different reproductive strategies. Taxa with high  $r$ -values reproduce quickly. More to the point, their populations reach their habitat's carrying capacity sooner than do species with lower  $r$ -values. This can mean that taxa with higher  $r$ -values can benefit from a degree of harvest pressure resistance when compared to taxa with slower rates of intrinsic increase. Figure 2.1 shows equilibrium states for constant hunting pressure (time spent foraging) on three hypothetical species with different  $r$ -values. The intersection between the harvest effort line and each species

line indicates the equilibrium yield, growth rate, and abundance relative to carrying capacity. The steep growth curve of the fastest increasing species, 1, provides the highest modeled yield. Species 2 has a more gradual growth rate and a correspondingly lower yield. The harvest effort modeled here provides the greatest yield possible for Species 2, as the harvest line crosses the peak of the Species 2 growth curve. Species 3 increases so slowly that the modeled harvest effort decreases yield from the maximum possible yield. The Species 3 yield could be increased by reducing harvest effort until the effort line crosses the Species 3 growth curve crest.

The hunting pressure modeled in figure 2.1 has different demographic outcomes for the Species 1, 2, and 3 beyond mere variance in absolute abundance. The age profiles each modeled species will be affected as well.



**Figure 0.1.** Equilibrium states for constant hunting pressure on three hypothetical species with different  $r$ -values (adapted from Clark 2010).

### Conventional Predator-Prey Models

Within a binary predator-prey population growth model (one predator species, one prey species), increased prey availability leads to increased predator population (Berryman 1981; Getz 1984; Leslie 1948; Lotka 1925; Volterra 1928; 1992). The high predator population can then cause a crash in the prey population, which leads to a large drop in the predator population. Little predation and more available forage, in turn allows prey to rebound. This represents the simplest model of predator-prey interaction, and is unrealistic given its few components and omission of lag time, spatial relationships, and other factors external to the model. In reality, unstable equilibria, neutrally stable cycles, stable equilibria, domains of equilibria, stable limit cycles, or stable nodes can all model predator-prey interactions, as local conditions dictate. These states can result in the extinction of one or more species, an equilibrium between predator and prey (Berryman 2004; Holling 1973; Steiner et al. 2012), or source/sink relationships (Slade and Balph 1974; Wootton and Bell 1992).

Predator-prey population dynamics become more complicated when predator populations are governed by the abundances of multiple prey species, as are humans. Winterhalder and Lu (1997) model the outcomes of optimal foraging behavior in circumstances when foragers may choose between prey species with differing return rates and differing population growth profiles. While their model uses standard prey choice reasoning to predict the taking of prey, it also attempts to model the effects of simultaneous hunting of prey with differing rates of intrinsic increase.



## Forager-resource Population Ecology Model

The Forager-resources Population Ecology (FPE) model (Winterhalder and Lu 1997) operationalizes the implications of hunting decisions for both predator and prey populations over time. As previously mentioned, The FPE model assumes that the ranking system used by the prey model governs prey choice. However, as the FPE model considers the effects of population ecology (as modeled with logistic growth curves), one must also understand carrying capacity ( $K$ ) and intrinsic rate of increase ( $r$ ) for each prey species present in an assemblage. The FPE model predicts that forager population growth results from increases to their net acquisition rate of energy (NAR), and predicts prey population as an outcome of carrying capacity, forager hunting activity, and  $r$ .

As the FPE model represents a dynamic system, it determines NAR as a function of both human population and the population of each discrete potential prey species. It further predicts that when high-rank, low- $r$  prey share their range with high-rank, high- $r$  prey, the low- $r$  species should eventually leave the diet as a result of extirpation. Extirpation should result as high-rank, high- $r$  prey allow forager populations to grow unfettered by the increasing rarity of a high-rank, low- $r$  prey species. Finally, the FPE model predicts that temporary switches in diet breadth to include plentiful high- $r$ , low-rank prey, which yields returns below a subsistence maintenance return rate, should act as a fallback strategy when NAR drops due to the depletion of high-ranked prey. Such a fallback resource can prevent local extinction of both prey and human foragers. Table 2.1 demonstrates the FPE model's predictions given a few example scenarios of available prey with variable attributes.

The FPE model provides more nuanced predictions than does the prey choice model. While the prey choice model simulates decision making, the FPE model simulates the effects of repeated decisions in a system in which the abundance of predators and prey change over time. The predicted outcomes of these decisions include the population depression of the lowest- $r$  prey within the diet, and the inclusion of resources that yield below maintenance return rates within the diet during times of extreme food stress. Additionally, the FPE model allows for predictions on the proportional contribution of specific prey within foragers' diets. As low- $r$ , high-value prey become scarce, foragers should rely upon high- $r$ , medium-rank game to buffer their dietary NAR. Over time, and especially as human populations increase, this effect should result in greater proportional contributions by quicker-reproducing prey.

**Table 0-1** Predictions for the effects of five cases of prey attributes on human and prey populations

Parameter	Available Prey			Diet Breadth	Diet Contribution	Prey Population Effect	Human Population Change
	Rank	<i>r</i>	Abundance				
1	High	High	High	Included	Entirety of Diet	Slow Decline	Increase
	Medium	High	High	Excluded		Stable	
	Low	High	High	Excluded		Stable	
	Lowest	High	High	Excluded		Stable	
2	High	Low	High	Included	Entirety of Diet	Decline	Increase
	Medium	High	High	Excluded		Stable	
	Low	High	High	Excluded		Stable	
	Lowest	High	High	Excluded		Stable	
3	High	Low	Low	Included	Minority of Diet	Decline	Increase
	Medium	High	High	Included	Majority of Diet	Slow Decline	
	Low	High	High	Excluded		Stable	
	Lowest	High	High	Excluded		Stable	
4	High	Low	Low	Included	Minority of Diet	Decline	Slight Increase
	Medium	High	Low	Included	Minority of Diet	Decline	
	Low	High	High	Included	Majority of Diet	Slow Decline	
	Lowest	High	High	Excluded		Stable	
5	High	Low	Low	Included	Minority of Diet	Decline	Decline
	Medium	Low	Low	Included	Minority of Diet	Decline	
	Low	Low	Low	Included	Majority of Diet	Decline	
	Lowest	High	High	Included	Majority of Diet	Stable	

## Implications

While the assumptions of the FPE model assumptions make sense, they remain untested on an actual archaeological assemblage. Without such a test, the accuracy of the model remains hypothetical, as does even the possibility of detecting whether the predicted behavioral outcomes can be differentiated from those of the standard prey model. In order to perform this test, one must have access to a dataset that represents substantial human hunting of different species over a long time span. The faunal assemblage from the Birch Creek rockshelters may represent just such a dataset.

In order to use Birch Creek as a test case for evaluating the FPE model, the dataset must fulfill certain criteria. First, the archaeological record must span enough time for foraging behavior to have detectable effects on prey present within the assemblage. Next, the population ecology traits of prey items present at the site must be known well enough to compare different prey. This means that  $r$ -values and proxies for landscape carrying capacity for these prey must be available. In Chapter 3, I outline how well the Birch Creek rockshelters fulfill these criteria, and explore strategies for ameliorating the dataset's shortcomings.

## METHODS

In Chapter 3, I describe my methods for collecting primary data from the Birch Creek archaeofauna and my methods for generating secondary data. I also outline my methods for testing the expectations for the Birch Creek data set that I derived from trends in my independent variables. My primary data collection efforts focus on quantifying the fauna represented in the Birch Creek archaeofauna through the identification of specimens, and the documentation of modifications to those specimens. My secondary data generation focuses on creating indices for processing intensity, prey mortality profiles, site and regional population density, and net acquisition rate.

### Taphonomy

Taphonomy is the science of the laws of burial, applied to paleontological, paleobotanical, and zooarchaeological assemblages (Efremov 1940; Lyman 1994). As I use the Birch Creek archaeofauna to study the interplay between human subsistence activity and prey population dynamics, I seek to understand the processes that resulted in the Birch Creek archaeofauna's present state (Lyman 1982, 1994; Maltby 1985). This understanding has several components. First, I must discriminate between humanly exploited fauna present at Birch Creek, and fauna present due to non-cultural processes (Binford 1981; Thomas 1971). Second, I seek to quantify the fauna present so they are as representative as possible of human economic behavior, rather than non-cultural taphonomic processes (Grayson 1984; Lyman 1979). To meet these aims, I determine the nature of the information, or noise, added by taphonomic processes, and to remove

that noise from the information, or signal, imparted by human subsistence activity (Gifford 1981). The methods outlined below seek to quantify the effects of human behavior upon the remains of prey animals, while accounting for the effect of taphonomic processes.

### **Primary Data Collection, Secondary Data Generation**

This paper deals with two distinct types of data: primary and secondary. Here, I use the term *primary data* to indicate those data that represent directly observed phenomena. Measures of quantification, specimen modification, such as weathering, cutmarks, rodent gnawing, and the like all represent primary data. Primary data are recorded following the examination of specimens and do not require calculation. The primary data used in this paper include counts of element and taxonomic abundances, surface modification, epiphyseal fusion, and fetal status.

*Secondary data* are not directly observable phenomena, but are, instead, derived measures that I generate as proxies for measuring phenomena that I cannot directly measure. I generate my secondary data from the primary data that I collected from the Birch Creek archaeofauna. Below, I describe my methods for generating secondary data, which represent proxies for human behavior, such as marrow and bone grease extraction, the inclusion of taxa within the diet, and the selective transport of prey elements. I further generate secondary data that speak to prey mortality profiles, the correct temporal placement of human settlement, and regional population density. Below, I first detail my

methods for collecting primary data, and next describe my methods for generating secondary data.

## Identification

I identified each specimen from the Birch Creek archaeofauna to the most specific taxon possible. Faunal reference collections provided by both Utah State University and Utah State University Archaeological Services (now Cannon Heritage Consultants, Inc.), and published guides (Broughton and Miller 2010; Brown and Gustafson 1979; Gilbert 1990; Gilbert et al. 1996; Jones et al. 2014; Olsen 1964) aided me in this task. Size and Class represent the coarsest level of identification used here. All specimens within the collection are vertebrates and include the classes Mammalia, Aves, and Reptilia. My size categories are small, medium, and large. The large category encompasses animals within the size range of bison, elk, cattle, and moose. As my entire set of non-bison large specimens consists of a single, questionable elk specimen, I consider all large artiodactyl remains to represent bison. Medium category animals include mule deer, bighorn sheep, pronghorn, and dog-sized canids. The small category encompasses all present Aves, the Order Rodentia, the single specimen identified to the class Reptilia, and lynx-sized and smaller carnivores.

In addition to taxon-level specimen identification, I attempted to identify each Birch Creek faunal specimen to side and element/portion/segment as defined by Gifford and Crader (1977). My coarsest level of identification is “unidentified fragment.” The reference materials I used to identify specimens to taxa (Broughton and Miller 2010; Brown and Gustafson 1979; Gilbert 1990; Gilbert et al. 1996; Jones et al. 2014; Olsen 1964), aided me in element identification as well. Finally, I use Todd’s (1987) specimen identification codes to document the Birch Creek faunal assemblage.



## Quantification

The analysis of archaeofaunas requires quantification of the taxa represented within the assemblage (Grayson 1984). Here, I describe my methods for quantifying the abundances of the various taxa present within the Birch Creek assemblage. To accomplish this task, I use two primary measures of abundance, number of identified specimens (NISP) and minimum number of individuals (MNI). NISP represents the total number of specimens present and assignable to a taxon (Grayson 1984; Lyman 1994). MNI estimates the number of individuals that contributed to the assemblage. While each method has its strengths and weaknesses (Grayson 1984; Klein and Cruz-Urbe 1984; Lyman 1994), I consider these measures to be complementary and report both.

NISP is the simpler of the two quantification methods used here, and represents the fundamental unit for tallying faunal remains (Grayson 1984; Lyman 2008). Lyman (2008) argues that as a direct, cumulative tally NISP represents an observed measure (primary data), whereas other quantification schema represent generated measures (secondary data) due their non-cumulative nature. However, NISP does not control for the effects of skeletal fragmentation (Grayson 1984). The extreme interpretation of a NISP count would be to consider each specimen to represent a separate individual. Thus, NISP can be understood to represent the maximum number of individuals possibly represented by an archaeofaunal assemblage.

MNI is based upon identifying the abundance of the most common element, accounting for side where needed of each taxon at the resolution of the analytical unit applied to the assemblage under study. Here I consider Swanson's (1972) cultural phases as such a unit. By considering each phase as a separate analytical unit, I assume each

phase sufficiently distinct from other phases to preclude the possibility that remains of one individual are present in other phases. This practice contrasts with Swanson's practice as he considered each level to contain no individuals present in any other level. Dealt with incorrectly, this overlap can result in either inflated or deflated MNI values. I follow Ringrose's (1993) contention that the individuals cannot be present in two separate locations, and consider individuals present at Bison Rockshelter distinct from individuals present at Veratic Rockshelter. Thus, I generate separate MNI values for each site and aggregate them together to produce the MNI for each cultural phase.

MNI positively co-varies with NISP in either curvilinear or linear fashion (Casteel 1976, 1977; Ducos 1968; Grayson 1984; Hesse 1982). As such, both measures speak to relative abundance (Grayson 1984). MNI can ameliorate some of NISP's problems, specifically the issue of fragmentation-based abundance inflation (Stock 1929; Howard 1930). However, MNI, when incorrectly aggregated, can also yield misleading results. Three factors influence the ratio between MNI and NISP values. First, the more complete (and element rich) the skeletons at a site, the greater the NISP/MNI ratio. Second, the more fragmented the measured remains, the greater the NISP/MNI ratio. Third, the more thoroughly an assemblage is identified, the greater the NISP/MNI ratio. I expect fluctuations in the NISP/MNI from one phase to another to indicate that one, or more, of the above phenomena are present.

#### Density Mediated Attrition

Effective zooarchaeological analysis requires an understanding of what information taphonomic process have added to an assemblage, and what information such

processes have deleted. Moreover, the zooarchaeologist must be able to understand whether absent element portions may be absent due to differential preservation (Brain 1967, 1969; Lyman 1994), rather than economic decision-making (Binford 1978). The detection of density-mediated attrition on an assemblage represents an important way to deal with this problem.

I record the presence of Lyman's (1984) scan sites on relevant specimens to assess the effect of density-mediated attrition on each analytical unit present within the Birch Creek archaeofauna. When a scan site is not entirely present, I do not record it as present. I record the presence of Kreutzer's scan sites for bison (1992). For mule deer, pronghorn, and bighorn sheep, I use Lyman's (1984) ungulate scan sites. I record Novecosky and Popkin's (2005) canid scan sites for canids and other order *Carnivora* specimens such as lynx and cougar. For order *Rodentia* specimens, I use Lyman's (1993) scan sites for marmot bones. I use Pavao and Stahl's (1999) scan sites for lagomorphs. I did not record scan sites for other specimens.

### Processing Measures

Direct evidence for cultural modification of bones represents a productive line of inference for detecting human butchering strategies. Within this context, I record cut marks, impact scars, burning, and breakage type for each specimen from the Birch Creek archaeofauna to assess processing intensity and to determine which taxa within the assemblage site occupants ate. While the lithic artifacts reported by Swanson (1972) indicate that the Birch Creek fauna is an archaeofauna in reality, rather than a paleontological assemblage, additional evidence of butchering behavior allows me to

distinguish between intrusive fauna and taxa within the Birch Creek diet.

### Butchery

Cutmarks, which result from the use of edged implements to remove soft tissue from bone, are present on a number of Birch Creek specimens. I report the number of fine v-shaped striations (Shipman and Rose 1983) on each specimen as a count of cutmarks. While cutmarks offer direct evidence of resource extraction, they do not necessarily speak to processing intensity. While cutmarks may result from meat removal, the act of removing meat from a given specimen does not always create cutmarks, nor do additional cuts necessarily create more cutmarks (Egeland 2003; Lyman 2005). Instead, I use the presence of cutmarks as an aid in identifying which of the taxa present within the assemblage are included in the Birch Creek diet.

Green bone breakage represents another indicator of human processing activity, although carnivores may cause green bone breakage as well (Haynes 1983, Johnson 1985). Green bone breakage occurs when fresh bone breaks from dynamic loading. Spiral fractures with smooth fracture surfaces at acute or obtuse angles to the bone's outer cortical surface represent diagnostic evidence of green bone breakage (Johnson 1985). When relevant, I report the breakage type(s) present for each specimen as green, dry, or indeterminate. I diagnose dry bone breakage when bones are broken either perpendicular or parallel to the bones' long axis, with fracture surfaces at 90° to the outer cortical surface. I mark ambiguous specimens, particularly those with heavy weathering, as indeterminate.

While spiral fractures can indicate the breakage of fresh bone by means of dynamic loading, impact scars provide application point evidence of dynamic loading. I identify impact scars following Breslawski and Byers' (2014) criteria as both conchoidal flake scars on longbone shafts, and depressions from which cracks radiate. The identification of impact scars provides evidence of dynamic point loading, a cause of green bone breakage consistent with direct percussion from a tool. While green bone breakage does not speak to a specific breakage agent (Johnson 1985), the identification of impact scars allows me to identify specimens as having been broken by direct percussion while fresh, a pattern consistent with human processing.

### **Fusion and Fetal Status**

The final data set I collect attempts to measure the age of prey animal present at Birch Creek. As predation-depressed populations skew towards a greater proportion of young individuals, a measure of age at death should provide one method to detect anthropogenic resource depression (Broughton 1994; Caughley 1966, 1977; Lyman 1987). As lower mean prey age correlates with predation-driven abundance decreases, rather than carrying capacity declines, demographic structure gives me data with which to distinguish between the hunting pressure and habitat deterioration. In order to quantify the relative contributions of differently aged individuals to the assemblage, I record epiphyseal fusion and fetal status. I code epiphyseal fusion according to Todd's (1987) methods; see Table 3.1. Fetal status I code with a "1" to indicate fetal or a "0" to indicate a post-natal individual.

**Table 0-1** Fusion Stages for Birch Creek.

Code	Description
0	Unfused
1	Partially fused
2	Fused, line still visible
3	Completely fused
4	Broken
5	N/A

### Net Acquisition Rate

OFT assumes that foragers will seek to maintain the highest Net Acquisition Rate (NAR) that satisfies the metabolic expenditure necessary for reproductive viability.

Below, I describe my means for generating secondary data capable of quantifying the effects of human reactions to changing NAR on the Birch Creek faunal assemblage. By tracking fluctuating NAR over the Birch Creek occupation, I should be able to assess the proposition that the availability of high-r prey can buffer NAR against when high-rank prey populations suffer depression. I consider measures of processing intensity, diet breadth, and transport behavior to indicate a need for foragers to suffer a lower NAR in order to meet their metabolic requirements.

### Processing Intensity

Intensive processing of prey indicates a willingness to forgo a higher NAR in exchange for obtaining a greater number of total calories (Binford 1978; Breslawski and Byers 2015; Burger et al. 2005; Smith et al. 2008). In essence, the forager treats each prey item (including prey subcomponents like a hindquarter) as a patch, and chooses to

remain in the patch longer, obtaining increasingly marginal caloric gains while working longer to obtain a higher caloric yield from the item.

The extraction of skeletal fat, especially bone grease, represents the decision to pursue the lower-ranked resources within a given prey item. I generate four datasets that should monitor the extraction of skeletal fat. These are NISP/MNE, %Intact, %WetBreak, %Speciated, and %Discarded. I calculate NISP/MNI for each prey species present in the Birch Creek assemblage by dividing the NISP for all taxa by their corresponding MNE values. Both NISP and MNE positively correlate with abundance, but higher ratios of NISP to MNE, especially for elements with high skeletal fat yields should indicate greater fragmentation due to more prevalent fat-seeking behavior.

Cultural fragmentation, carnivore ravaging, and excessive weathering all hindered my ability to identify medium-sized artiodactyl remains to species. I thus generate a %Speciated measure for medium-sized artiodactyls for each phase by dividing the total of medium size class specimens identified to the species level by the total of all medium size class specimens, excluding carnivore-ravaged and weathering class 5 and 6 specimens. I do not include large artiodactyls in this analysis; I assume that effectively all large artiodactyls represent bison for the reasons mentioned above. Furthermore, skeletal fat extraction should result in fewer intact elements. I calculate %Intact by dividing unbroken NISP by total NISP for three taxa. Bison, medium artiodactyls, and all specimens comprise my taxa of analysis.

Swanson's discard of a substantial portion of his cataloged faunal specimens greatly impairs my ability to use the frequency of impact scars and unidentifiable bone fragments to gauge processing intensity. However, I consider the quantity of discarded

bone in a given phase to co-vary with the overall fragmentation present within that phase. This fragmentation should correspond to a greater processing intensity; I measure it by dividing NISP of all prey cataloged by the sum of NISP (all prey) and NISP (discarded specimens).

### Diet Breadth

A diet broadened by the increased inclusion of low-ranked prey items represents a fall in NAR (Bayham 1979; Charnov 1976; Charnov and Orians 1973; Emlen 1966; MacArthur and Pianka 1966; Schoener 1971; Stephens and Krebs 1986). I generate indices to measure the occurrence of this phenomenon at Birch Creek, and graph these indices across the span of the site occupation. I generate a Bison Index representing the contribution of the highest-ranked prey, bison, at Birch Creek with the formula:

$$(\Sigma \text{Bison}) / (\Sigma \text{All Specimens})$$

I generate this index, and the index below, using both NISP and MNI as measures of abundance. I also generate an Artiodactyl Index compared to the remaining prey animals present at Birch Creek with the formula:

$$(\Sigma \text{Artiodactyls}) / (\Sigma \text{All Specimens})$$

As the utilized component of an archaeofaunal assemblage can be understood as the work of a collective predator (Broughton 1994), lower index values represent more instances of the decision to pursue lower-ranked prey proved necessary to combat the scarcity of high-ranked prey.



## **Site Chronology**

As discussed in Chapter 1, summed probability distributions can be used to generate rough estimates of human population. They are more classically used to chronologically position archaeological material. I use Oxcal 4.2 (Bronk Ramsey 2009; Reimer et al. 2013) to generate a summed probability distribution of Birch Creek radiocarbon dates (Appendix A this document; Keene 2016; Swanson 1972) to refine the timing of Birch Creek habitation events. This more accurate chronological placement will better enable me to compare phenomena present at Birch Creek with regional population density estimates and climatic reconstructions.

## **Regional Population**

I regard regional human population density as a factor depressing prey populations, particularly those with low  $r$ -values. As introduced in Chapter 1, summed probability distributions can be used to generate rough estimates of human population. I use Oxcal 4.2 (Bronk Ramsey 2009; Reimer et al. 2013) to generate a summed probability distribution of Idaho radiocarbon dates to estimate regional population density.

## Population Mortality Profiles

A reduction in average animal age is commonly used to detect resource depression (Anderson 1981; Broughton 1994, 1997, 2002; Butler 2001; Klein and Cruz-Uribe 1984; Stiner et al. 2000). I generate an index of prey age for each mammalian prey species, ScoreMature, with my record of the Birch Creek assemblage's fusion data. I generate this measure with the formula:

$$0(\Sigma \text{Fusion } 0) + \Sigma \text{Fusion } 1 + 2(\Sigma \text{Fusion } 2) + 3(\Sigma \text{Fusion } 3) / \Sigma \Sigma \text{Fusion } 0 + \Sigma \text{Fusion } 1 + 2\Sigma \text{Fusion } 2 + \Sigma \text{Fusion } 3 = \text{ScoreMature}$$

A score of "3" indicates an entirely fused population; a score of "0" indicates a population with completely unfused epiphyses. Specimens scored with a "1" are partially fused, while a "2" indicates a fused specimen with a still visible line on the diaphysis/epiphysis margin. The lower the score, the more immature the overall population indicated. As epiphyseal fusion in bison, deer, and sheep is a multi-year process (Duffield 1973; Empel and Roszkosz 1963; Koch 1932, 1935; Purdue 1983; Roll and Deaver 1980; Todd 1987; Walker 1987), I do not judge this measure a seasonality indicator, but rather, a measure of each prey taxa's overall youth. Comparison of the scores of each prey species in each Cultural Phase should allow the determination of whether high-*r* species better resist anthropogenic population depression effects (if any) evidenced within the Birch Creek Assemblage. Furthermore, comparing each species' score against the average score for all present artiodactyls permits testing the proposition that *r*-value produces a significant difference in predator-mediated resource depression.

## Summary

In Chapter 3, I described my methods for collecting primary data from the Birch Creek archaeofauna, and my methods for generating secondary data. I describe my primary data collection efforts, which focus on the identification of faunal specimens to taxon, side, and element and describing my efforts to document cultural modifications to the assemblage. For secondary data generation, I generate measures of processing intensity, prey age structure, site population, and regional population. These methods all aim at finding measures capable of identifying the link between human hunting strategies, prey  $r$ -values, human population density, and prey population depression. I report these data within Chapter 6, Results.

## INDEPENDENT VARIABLES

In Chapter 4, Independent Variables, I cover some of the external factors that should influence prey abundance and may mediate the effects of human hunting pressure. These independent variables include the population dynamics of prey present at Birch Creek, Snake River Plain climate, and Idaho population density. A combination of “top-down” and “bottom-up” controls condition the abundance of all living taxa (Hunter and Price 1992; Ripple and Beschta 2004; Power 1992; White 1978). Finite resources exert “bottom-up” control on a taxon’s maximum abundance. Conversely, predators exert “top-down” control on a taxon by consuming individuals from that taxon. I consider human predation to represent a major top-down control on the prey animals present at Birch Creek. Climate represents a proxy for “bottom-up” abundance control. In this chapter’s ultimate section, I make predictions specific to the Birch Creek archaeofauna from trends in these variables.

### **Prey Population Dynamics**

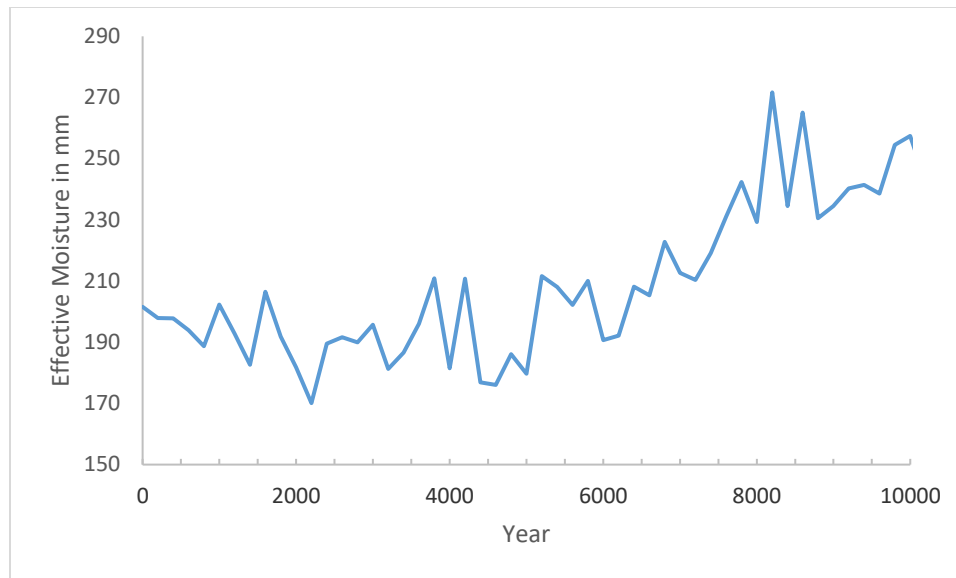
Understanding the effects of hunting behavior and climatic variability on Snake River Plain prey abundance requires understanding the population dynamics of those prey species. Table 4.1 presents rates of intrinsic increase (r-values) for the major prey species present at Birch Creek.

**Table 0-1. Prey Ecological Traits.**

Species	Habitat	Visibility	Diet	Breeding Age	Litter Size	<i>r</i>	Reference
Bison	Grasslands to shrub-steppe to boreal forest	Occasional use of wooded areas for shade and insect avoidance	Sedges and Grasses	2 Years	1	0.32	Larter et al. 1994
						0.295	Singer and Norland 1994
						0.233	Calef 1954
Pronghorn	Semiarid plains and prairies	Low lying vegetation <76 cm in height	Shrubs, Forbs and Grasses	16-17 Months	2	0.45	Singer and Norland 1994
						0.48	Cole 1954
						0.48	Henneman 1983
Deer	Shrubby and mixed tree and shrub landscapes	Cover for thermal regulation	Forbs and Shrubs	2 Years	1-2	0.223	Hatter and Janz 1994
Bighorn Sheep	Available high, rocky escape terrain	High	Grasses	2-3 Years	1	0.35	Cole 1954
							Henneman 1983
Sage Grouse	Sagebrush steppe and riparian areas	Sagebrush above snow level	Big Sagebrush and forbs	1 Year	8	Unknown	Dalke et al. 1963
							Schroeder et al. 2004
							Knick and Connelly 2011

## Climate

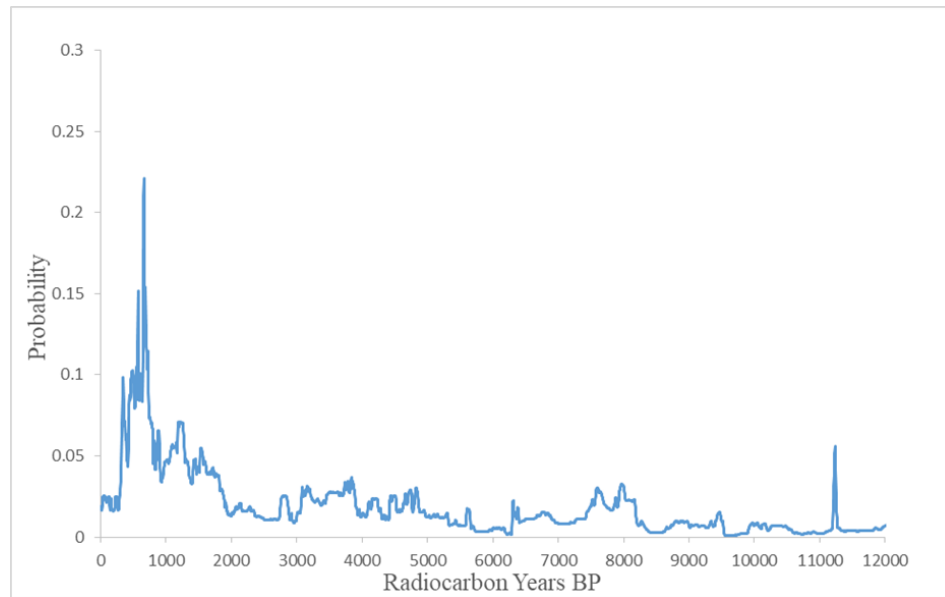
A few proxy records exist that offer information on southern Idaho's plant communities (Beiswenger 1991; Bright 1966; Davis et al 1986; Doner 2009; Plager and Holmer 2004). These records allow for the identification of broad climatic trends. For instance, Beiswenger (1991) found a cold, dry, coniferous forest predominated around Gray's Lake from 30,000  $^{14}\text{C}$  yr BP to 11,500  $^{14}\text{C}$  yr BP. Plager and Holmer (2004) similarly find that mixed conifers and subalpine meadow predominated between 11,700  $^{14}\text{C}$  yr BP and 11,300  $^{14}\text{C}$  yr BP. After 11,500  $^{14}\text{C}$  yr BP, cool, moist conditions predominated until 10,000  $^{14}\text{C}$  yr BP, after which the climate became increasingly xeric, with *Juniperus*, *Artemisia*, *Chenopodiaceae/Amaranthaceae*, *Sarcobatus*, and *Graminae* species increasing their coverage. According to Beiswenger (1991), aridity appears to have peaked near 8200  $^{14}\text{C}$  yr BP. However, Bright and Davis (1986) point to an aridity peak near 7000  $^{14}\text{C}$  yr BP. By 7100  $^{14}\text{C}$  yr BP, conditions had cooled, resulting in a resurgence of conifer coverage (Beiswenger 1991). Cooling then continued from 2000  $^{14}\text{C}$  yr BP to the historic period (Beiswenger 1991). However, according to Plager and Holmer (2004), from 250 to 150  $^{14}\text{C}$  yr BP, sagebrush steppe predominated on the eastern Snake River Plain.



**Figure 0.1** Idaho effective moisture in mm plotted at a bicentennial scale modeled using the Bryson and Bryson (2000) archaeoclimate model.

The palynological records suffer from many shortcomings. They can be coarse, spatially or chronologically incomplete, and difficult to quantify against chronologically continuous archaeofaunal data. For this study, I prefer to use a model for the climate itself over a broader region. More problematically, these proxy records do not provide point data that can be systematically compared to other point data, for instance radiocarbon dates. Most problematically, the use of multiple pollen records does not allow for statistical tests of significance, which I later use to determine whether environmental conditions are significantly different. Archaeoclimate models can circumvent many of these issues.

Rather than a proxy-based climate record, I use Bryson and Bryson's archaeoclimate model (Bryson 1989, 1992; Bryson and Bryson 2000) to estimate southern Idaho climate trends. I later use this modeled climate to generate testable expectations for a Birch Creek archaeofauna. The Bryson and Bryson model estimates annual precipitation and temperature averages at a bicentennial scale for the Pleistocene



**Figure 0.2.** The summed probability distribution of Idaho's radiocarbon dates (Bronk Ramsey 2009; Appendix A; Reimer et al 2013).

and Holocene. Here, I only concern myself with Holocene climate. Their model is based on the influence that global thermodynamic and hydrodynamic patterns exert on the earth-atmosphere-hydrosphere-cryosphere system. The relationship between these patterns and interlinked systems drive local weather patterns. Bryson and Bryson's (2002) model uses global glacial volume, Milankovitch variations, and volcanic aerosol to calculate a heat energy budget for its study period. Next, trends in these factors are used to model variability in meridional temperature gradients. This variation is used to calculate the jet stream's latitude and the locations of subtropical anticyclones across time. Historically recorded rainfall and temperature data are used to calibrate the model for a given region. Here, I use an archaeoclimate dataset for the Burley, Idaho climate station. Bryson and Bryson's (2000) climate model presents both mean annual temperature and total annual rainfall. I use Bailey's (1958) modified Thornthwaite (1948) moisture index:



$$p = p/1.025^t$$

to plot effective moisture against the time span of Birch Creek's habitation (Table 4.2 ).

#### Climate Mediated Abundance

Temperature and precipitation, i.e. effective moisture, acts as a bottom-up control on artiodactyl abundances (Howell et al 2002; Peek et al. 2002; Picton 1984; Singer et al. 1997; Van Vuren and Bray 1986). Effective moisture positively correlates with forage quality and availability (Douglas 2001), as effective moisture itself acts as a bottom-up control on forage species abundance. Forage availability influences many metrics related to survival and recruitment including but not limited to maternal condition, initial offspring weight, disease resistance, first winter survival, and herd size (Byers and Hogg 1995; Douglas 2001; Fox et al. 2000; Leslie and Douglas 1979; Peek et al. 2002; Stephenson et al. 1985;). As effective moisture mediates forage availability, I consider effective moisture to be a primary bottom-up control on prey abundance. As increased effective moisture improves forage availability and quality, and improved forage conditions improve artiodactyl survival and reproductive success, additional effective moisture increases maximum possible artiodactyl abundance.

#### Human Population Density

I use human population density as a proxy for attack rate, the central top-down control on prey population dynamics (Hunter and Price 1992; Power 1992). Determining whether top-down or bottom up-population controls are generally the dominant control on prey populations

**Table 0-2.** Modeled Climatic Conditions (Bryson and Bryson 2000).

Year BP	Annual Precipitation	Average Temperature	Effective Moisture	Year BP	Annual Precipitation	Average Temperature	Effective Moisture
0	249.73	8.67	201.60	7200	263.46	9.12	210.36
200	240.35	7.87	197.93	7400	269.40	8.37	219.09
400	242.08	8.17	197.84	7600	282.14	8.09	231.07
600	237.65	8.23	193.93	7800	289.82	7.24	242.37
800	235.59	8.98	188.74	8000	276.11	7.52	229.32
1000	254.83	9.35	202.30	8200	319.93	6.62	271.66
1200	237.11	8.38	192.81	8400	281.05	7.33	234.51
1400	227.09	8.81	182.68	8600	314.18	6.88	265.07
1600	258.87	9.16	206.49	8800	276.54	7.36	230.57
1800	232.04	7.70	191.84	9000	280.64	7.28	234.47
2000	221.20	7.94	181.81	9200	284.77	6.89	240.23
2200	210.42	8.62	170.10	9400	290.42	7.47	241.48
2400	237.23	9.10	189.50	9600	286.06	7.34	238.63
2600	236.58	8.53	191.63	9800	306.38	7.51	254.55
2800	234.14	8.47	189.97	10000	306.60	7.07	257.46
3000	242.70	8.72	195.70	10200	288.29	7.00	242.55
3200	226.67	9.05	181.29	10400	291.61	6.01	251.37
3400	232.52	8.91	186.59	10600	288.04	6.64	244.51
3600	241.29	8.41	196.03	10800	286.76	5.65	249.44
3800	252.04	7.23	210.83	11000	292.20	6.49	248.92
4000	223.84	8.49	181.53	11200	286.41	5.96	247.19
4200	262.80	8.93	210.80	11400	260.67	5.42	228.01
4400	220.23	8.88	176.87	11600	260.29	5.10	229.49
4600	220.13	9.06	176.02	11800	266.67	4.01	241.55
4800	229.96	8.57	186.12	12000	270.51	4.66	241.14
5000	223.62	8.85	179.71	12200	267.06	5.32	234.16
5200	266.94	9.41	211.62	12400	261.07	4.99	230.83
5400	258.20	8.75	208.02	12600	284.87	5.03	251.63
5600	252.75	9.04	202.16	12800	265.61	4.03	240.48
5800	265.61	9.50	210.08	13000	284.65	5.51	248.41
6000	238.95	9.14	190.67	13200	261.54	4.53	233.87
6200	238.02	8.66	192.20	13400	258.30	4.82	229.34
6400	260.96	9.16	208.15	13600	260.20	4.34	233.74
6600	257.98	9.25	205.32	13800	274.67	3.44	252.28
6800	273.81	8.35	222.81	14000	258.61	4.13	233.52
7000	266.21	9.09	212.68				

has proven difficult (Dawes-Gromadzki 2002; de Ruiter et al. 1995; Moran and Scheidler 2002; Polis et al. 1998; 2000; Ritchie 2000). Top-down controls have measureable negative effects on prey abundance (Kunkel and Pletscher 1999; Smith et al. 2004; Varley and Boyce 2006; Vucetich and Peterson 2004). Top-down control, specifically in the form of human hunting pressure can reduce artiodactyl abundance in spite of climatic

conditions that encourage abundant forage (Broughton 2002; Byers and Smith 2007; Hildebrandt and Jones 2002; Janetski 1997). Specifically, dramatic increases in human population appear tied to reduced artiodactyl abundance (Byers and Broughton 2004; Byers and Smith 2007)

To measure this proxy, I use a summed probability distribution (SPD) derived from a set of radiocarbon dates collected from Idaho archaeological sites. I view probability increases as the result of increased human activity, itself an indication of increased human population. Conversely, probability decreases as an outcome of the opposite trend (Kelly et al. 2012; Peros et al 2009; Shennan et al. 2013; Surovell and Brantingham 2007). I used Oxcal 4.2 (Bronk Ramsey 2009; Reimer et al 2013) to create an SPD for dates from Idaho archaeological sites provided by David Byers (personal communication), and available in Appendix A.

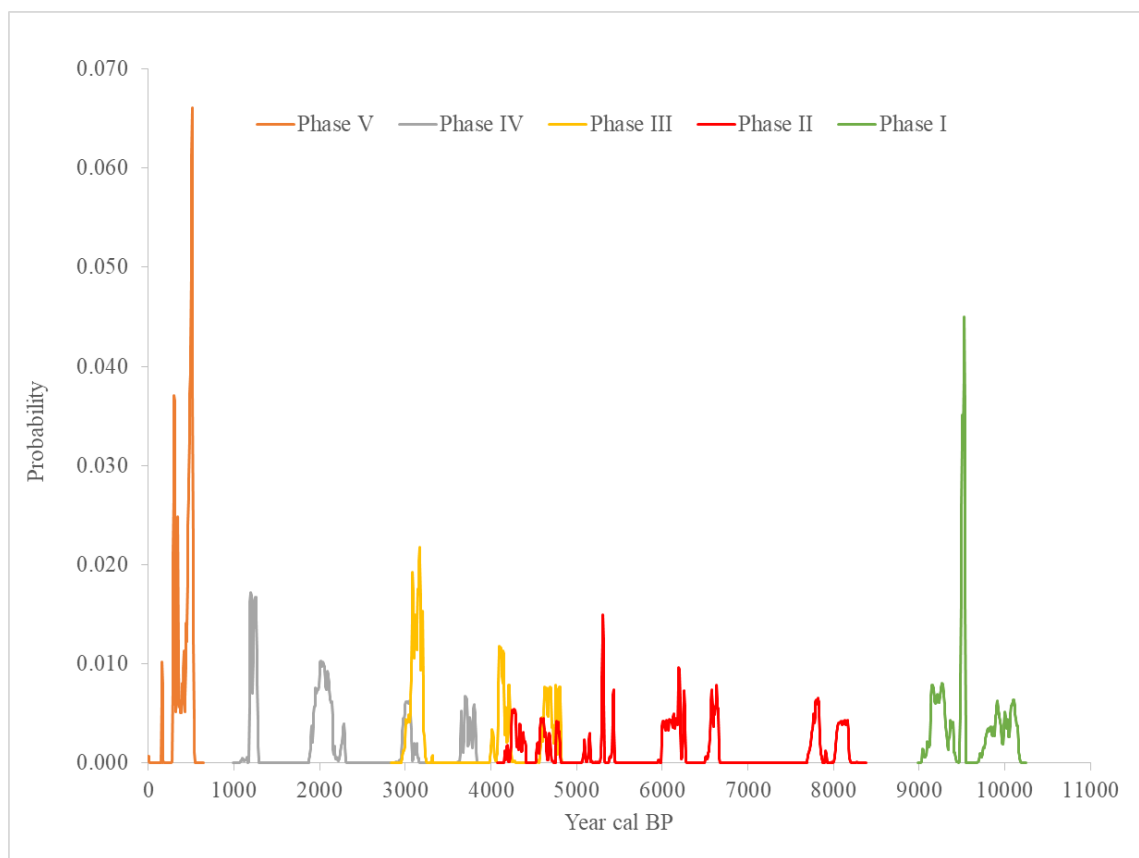
I vetted the radiocarbon dataset from Idaho to ensure good radiocarbon date hygiene (Brown 2015; Contreras and Meadows 2014; FitzPatrick 2006). This vetting included the removal of dates with dubious connection to human activity, removal of shell specimens not corrected for the reservoir effect, and the removal of all dates unattached to known lab numbers. Two hundred thirty-nine approved dates remained after this vetting. The dates span from  $23,400 \pm 450$  BP (Growlett et al. 1987:146) to  $50 \pm 60$  BP (Arkush 2000). These dates come from archaeological sites across Idaho. However, for confidentiality reasons, I do not list these dates in tabular form.

## Expectations

Table 4.3 makes the FPE model's general predictions explicit; the different parameters in the table each represent a theoretical habitat description. Parameter 5 represents a condition in which game is too scarce to support an NAR sufficient for human population growth. To test these predictions, I need a dataset that satisfies several requirements. This dataset should contain archaeofaunal material from species with different prey ranks and different rates of intrinsic increase. The dataset should also include material from periods when the previously mentioned models of climate and population density present contrasting environmental states. The archaeofauna from the Birch Creek sites provides such a dataset. This archaeofauna includes all of the fauna presented above, providing differently ranked prey with different intrinsic rates of reproduction. With such a dataset, I can make predictions for the state of this archaeofauna given specific states of climatic condition and human population density.

## Dating

I use separate SPDs to place each Birch Creek occupation in time. I draw from the 13 dates from Veratic Rockshelter (Keene 2016) and 13 dates from Bison Rockshelter (Byers personal communication), none of which were used in the Idaho SPD. Table 0-4 presents Byers's (personal communication), Keene's (2016), and Swanson's (1972) radiocarbon dates, respectively, in tabular form. I did not assign five of Keene's (2016) dates to Birch Creek Phases, as they represented dates that were substantially younger than dates obtained from more recent levels. Keene (2016) rejected these dates as well. Figure 0.3 arrays these SPDs



**Figure 0.3.** SPDs for radiocarbon dates from each Birch Creek phase (Byers personal communication; Keene 2016; Swanson 1972).

**Table 0-3.** The FPE Model's predictions for the effects of five cases of prey attributes on human and prey populations

Parameter	Available Prey			Diet Breadth	Diet Contribution	Prey Population Effect	Human Population Change
	Rank	$r$	Abundance				
1	High	High	High	Included	Entirety of Diet	Slow Decline	Increase
	Medium	High	High	Excluded		Stable	
	Low	High	High	Excluded		Stable	
	Lowest	High	High	Excluded		Stable	
2	High	Low	High	Included	Entirety of Diet	Decline	Increase
	Medium	High	High	Excluded		Stable	
	Low	High	High	Excluded		Stable	
	Lowest	High	High	Excluded		Stable	
3	High	Low	Low	Included	Minority of Diet	Decline	Increase
	Medium	High	High	Included	Majority of Diet	Slow Decline	
	Low	High	High	Excluded		Stable	
	Lowest	High	High	Excluded		Stable	
4	High	Low	Low	Included	Minority of Diet	Decline	Slight Increase
	Medium	High	Low	Included	Minority of Diet	Decline	
	Low	High	High	Included	Majority of Diet	Slow Decline	
	Lowest	High	High	Excluded		Stable	
5	High	Low	Low	Included	Minority of Diet	Decline	Decline
	Medium	Low	Low	Included	Minority of Diet	Decline	
	Low	Low	Low	Included	Majority of Diet	Decline	
	Lowest	High	High	Included	Majority of Diet	Stable	

When I plot Byers's (in press) and Keene's (2016) radiocarbon dates from Bison and Veratic rockshelters, respectively, alongside the SPD of radiocarbon dates from the rest of Idaho, I can estimate the region's population density during each of Birch Creek's phases. Figure 4.4 depicts an SPD of each phase's radiocarbon dates alongside the Idaho radiocarbon summed probability.

### **Integration**

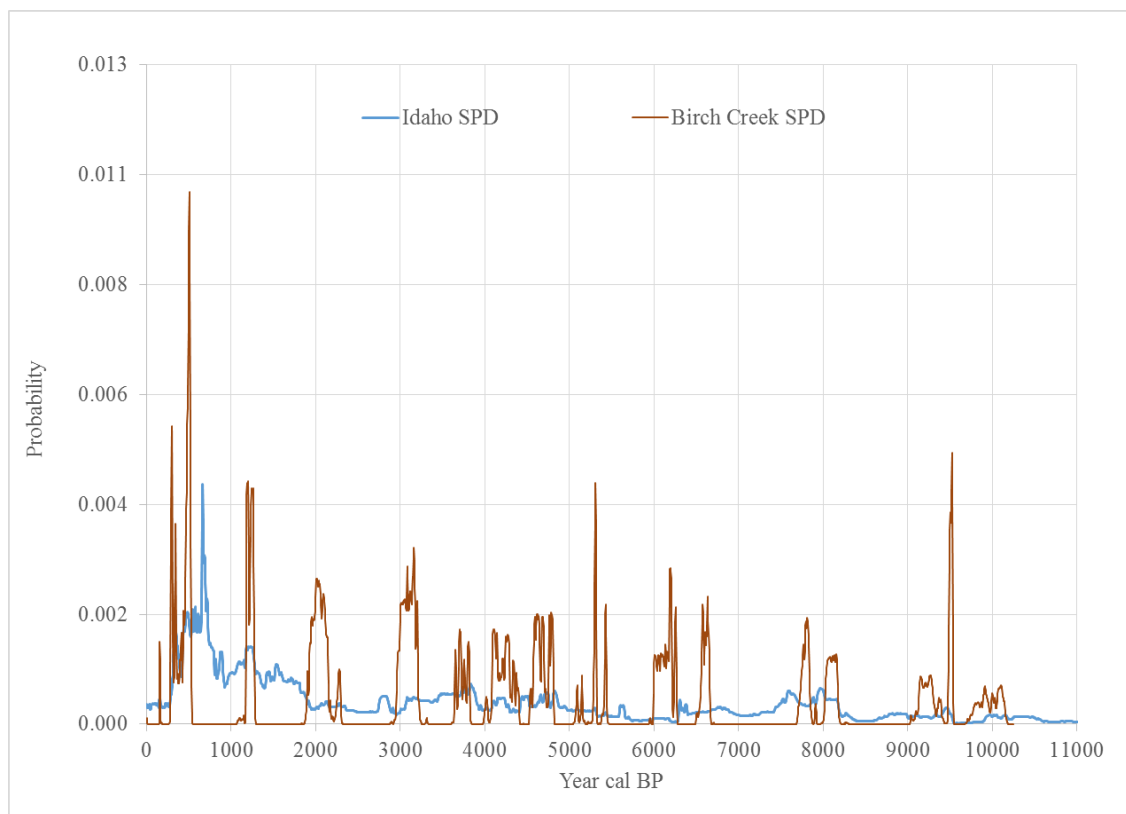
By presenting SPDs with the effective moisture derived from Bryson and Bryson's (2000) climate model, I can place a relative population estimate alongside effective moisture, effectively depicting both the top-down and bottom-up controls on prey abundance for the duration of Birch Creek's occupation. Use of Pearson's  $r$  indicates a -0.65 relationship between effective moisture and radiocarbon probability. This score means that human population appears to correlate negatively with available moisture. As one would expect effective moisture to correlate positively with human population density, I thus have effectively two independent variables that may drive prey abundance. Figure 0.5 depicts effective moisture alongside the previously depicted SPDs of Idaho and Birch Creek's radiocarbon dates. Chapter 5, Investigations at Birch Creek describes the sites' occupation history.

**Table 0-4.** Birch Creek Radiocarbon Dates (Byers personal communication; Keene 2016; Swanson 1972).

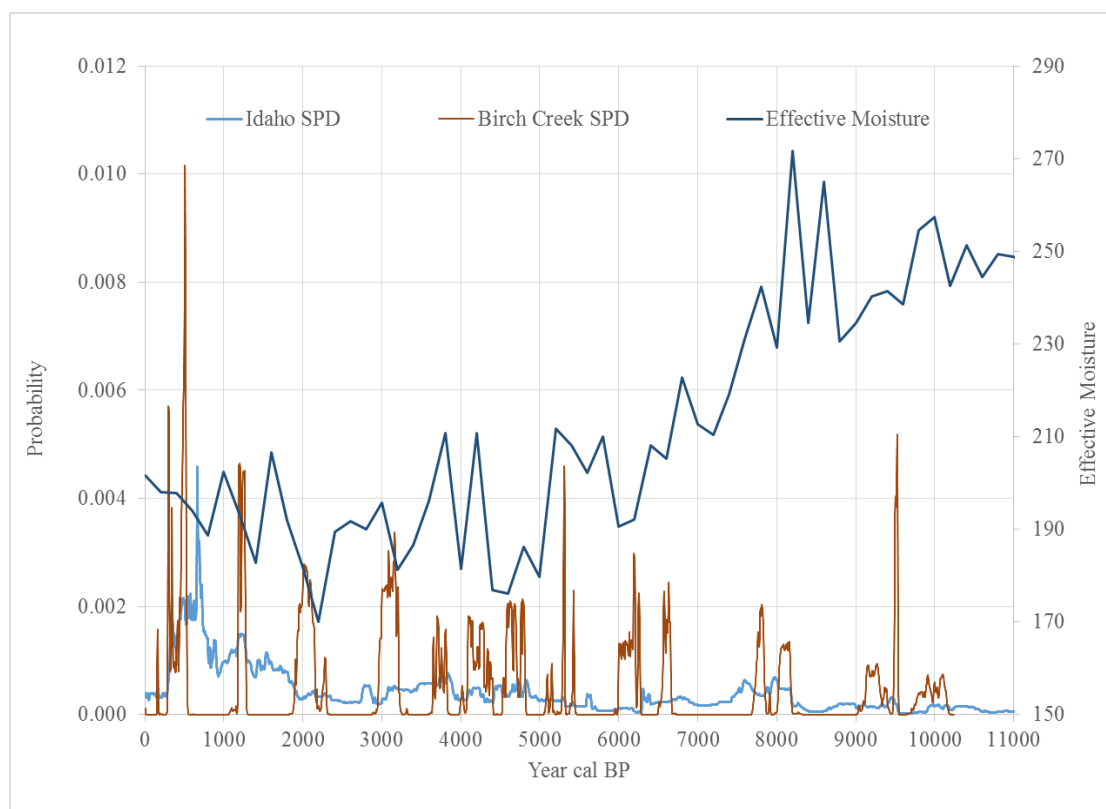
Reference, Lab Number	Phase	Level/Feature	Taxon	$\delta^{13}\text{C}$ (‰)	$^{14}\text{C}$ age year BP	95.4% (2 $\sigma$ ) cal age ranges	Area under distribution
(Keene 2016)							
UCIAMS-140280	Phase IV	Level 20	Artemisia cf. tridentata	$-147.19 \pm 0.0018$	$1280 \pm 20$	1180-1280	1
UCIAMS-140278b	Unassigned	Level 21	Artemisia cf. tridentata	$-43.3 \pm 0.0020$	$360 \pm 20$	320-490	1
UCIAMS-140281	Phase IV	Level 22	Artemisia cf. tridentata	$-228.24 \pm 0.0016$	$2080 \pm 20$	2000-2120	1
UCIAMS-140284	Phase III	Level 24	Artemisia cf. tridentata	-310.4	$2990 \pm 20$	3080-3220	1
UCIAMS-140276b	Unassigned	Level 25 top	Hardwood tree or shrub	$-22.93 \pm 0.0014$	$190 \pm 20$	modern-290	1
UCIAMS-140279b	Unassigned	Level 25	Artemisia cf. tridentata	$-40.68 \pm 0.0020$	$340 \pm 20$	320-470	1
UCIAMS-140274	Phase III	Level 26	Pseudotsuga menziesii	$-403.24 \pm 0.0014$	$4150 \pm 20$	4580-4820	1
UCIAMS-140272	Phase II	Level 27	Artemisia cf. tridentata	$-381.36 \pm 0.0014$	$3860 \pm 20$	4170-4410	1
UCIAMS-140275	Phase II	Level 27	cf. Juniperus sp.	$-400.85 \pm 0.0015$	$4120 \pm 20$	4570-4810	1
UCIAMS-140282	Phase II	Level 28	Artemisia cf. tridentata	$-487.96 \pm 0.0013$	$5380 \pm 20$	6030-6280	1
UCIAMS-140277	Phase II	Level 28	Artemisia cf. tridentata	$-514.22 \pm 0.0011$	$5800 \pm 20$	6540-6670	1
UCIAMS-140273	Phase II	Level 29	Pseudotsuga menziesii	$-482.74 \pm 0.0012$	$5300 \pm 20$	5990-6180	1
UCIAMS-140283b	Unassigned	Level 29	Artemisia cf. tridentata	$-40.31 \pm 0.0020$	$330 \pm 20$	310-460	1
UCIAMS-140271	Phase II	Feature 6	Pinus sp.	$-579.8 \pm 0.0012$	$6970 \pm 30$	7710-7860	1
Beta-331430	Phase II	Feature 6	“soft pine” (Pinus sp.)	-22.9	$7300 \pm 40$	8020-8180	1
UCIAMS-148190	Phase I	Level 30	unid.	$-653.5 \pm 0.0010$	$8520 \pm 30$	9490-9540	1
UCIAMS-140285b	Unassigned	Level 31	Artemisia cf. tridentata	$-384.98 \pm 0.0013$	$3910 \pm 20$	4260-4420	1
Beta-331431	Phase I	Level 31	“spruce”	-23	$8850 \pm 40$	9760-10,160	1
(Swanson 1972)							
UCLA-217	Phase IV	19-20	Bulk Charcoal?		$370 \pm 80$	290-540	0.99
UCLA-160	Phase IV	22	Bulk Charcoal?		$1580 \pm 80$	1310-1620	0.99
UCLA-218	Phase IV	26	Bulk Charcoal?		$2920 \pm 120$	2840-3360	0.97
WSU-502	Phase IV	27	Bulk Charcoal?		$4000 \pm 470$	3330-5640	>0.99
I-452	Phase IV	29	Bulk Charcoal?		$4500 \pm 170$	4810-5590	0.98
UCLA-162	Phase IV	29	Bulk Charcoal?		$5670 \pm 120$	6270-6740	0.99
UCLA-161	Phase IV	29	Bulk Charcoal?		$5870 \pm 120$	6410-6980	1
WSU-503	Phase II	Feature 6	Bulk Charcoal?		$6030 \pm 190$	6450-7310	1
TBN-3042	Phase II	Feature 6	Bulk Charcoal?		$6280 \pm 230$	6650-7590	1
WSU-760a	Phase I	30	Bone Collagen		$10,340 \pm 830$	9600-13,790	1
(Byers personal communication)							
ACRF-3616	Phase V	Level 1	Bison		$410 \pm 30$	330-520	1
ACRF-3619	Phase V	Level 2	Bison		$260 \pm 30$	150-430	0.99
ACRF-3624	Phase V	Feature 6	Bison		$460 \pm 30$	480-540	1
ACRF-3629	Phase V	Level 3	Bison		$380 \pm 30$	320-510	1
ACRF-3640	Phase IV	Level 4-6	Bison		$2140 \pm 40$	2000-2310	1
ACRF-3642	Phase IV	Level 5	Bison		$1280 \pm 30$	1180-1290	1
ACRF-3653	Phase IV	Level 7	Bison		$2020 \pm 30$	1890-2050	1
ACRF-3658	Phase IV	Level 15	Bison		$2900 \pm 30$	2950-3160	1
ACRF-3659	Phase III	Level 16	Bison		$2940 \pm 30$	2990-3180	0.99
ACRF-3660	Phase III	Level 17	Bison		$3770 \pm 30$	4,010-4,240	0.99
ACRF-3657	Phase IV	Level 9-13	Bison		$3460 \pm 30$	3640-3830	1
ACRF-3664	Phase II	Level 28	Bison		$4590 \pm 30$	5070-5450	1
ACRF-3665	Phase I	Level 32	Medium Artiodactyl		$8250 \pm 40$	9090-9400	0.99

Note: Byers (personal communication) and Swanson (1972) dates calibrated with Calib 7.1 (Stuiver 2018); Keene (2016) dates calibrated with OxCal (Bronk Ramsey 2009; Reimer et al. 2013)





**Figure 0.4** The summed probability distribution of Idaho’s radiocarbon dates alongside the summed probability distribution of Birch Creek’s radiocarbon dates (Appendix A this document; Byers personal communication; Keene 2016; Swanson 1972).



**Figure 0.5** Effective moisture, Idaho and Birch Creek radiocarbon date summed probability distributions.

## Summary

In Chapter 4, I discussed factors that should condition zooarchaeological assemblages. These include a model of Idaho's climate, a proxy for the region's population density, and the ecological traits of the prey species present in the zooarchaeological assemblage under study. Next, I made specific predictions for the effects of these independent variables on the Birch Creek dataset. Later, in Chapter 6, I make predictions about the nature of relationships between the Birch Creek archaeofauna and the variables discussed in this chapter. I next evaluate the accuracy of these predictions with statistical tests. However, I first introduce the Birch Creek dataset in Chapter 5, Investigations at Birch Creek.

## INVESTIGATIONS AT BIRCH CREEK

I use the faunal collection from the Birch Creek rockshelters (Swanson 1972) to test the hypotheses outlined within Chapter 4. Here, I describe the setting of these rockshelters, Swanson's excavation program, and the scheme with which he organized his assemblage. I also discuss the assemblage's shortcomings as a means for testing my hypotheses. I also summarize Swanson's findings in text and in tabular form. By describing Swanson's work, and his organizational scheme, I also provide the organizational basis that I use in testing my hypotheses.

Birch Creek, a mountain valley just north of Idaho's Snake River Plain and southwest of the Beaverhead Mountains, contains two notable rockshelters, which lie between 1859.28 m and 1828.8 m above sea level (Figure 5.1, Swanson 1972). These rockshelters, Veratic Rockshelter and Bison Rockshelter, sites 10CL3 and 10CL10 respectively, produced both artifacts and animal remains. Deep stratigraphy and extensive faunal collections permit investigation into the long-term patterns of subsistence behavior on the northeastern periphery of the Snake River Plain. Birch Creek runs north-south. The creek emerges from the ground in a series of eleven springs near the Gilmore Divide. The area around the springs contained a large meadow prior to twentieth century irrigation farming. The creek itself runs southward from the Beaverhead Mountains to the southern end of the Lemhi Range, which lies to the west. The creek empties into the Birch Creek Sinks, which are part of a no longer extant series of lakes. Like the meadow, these lakes disappeared following the adoption of modern irrigation practices.

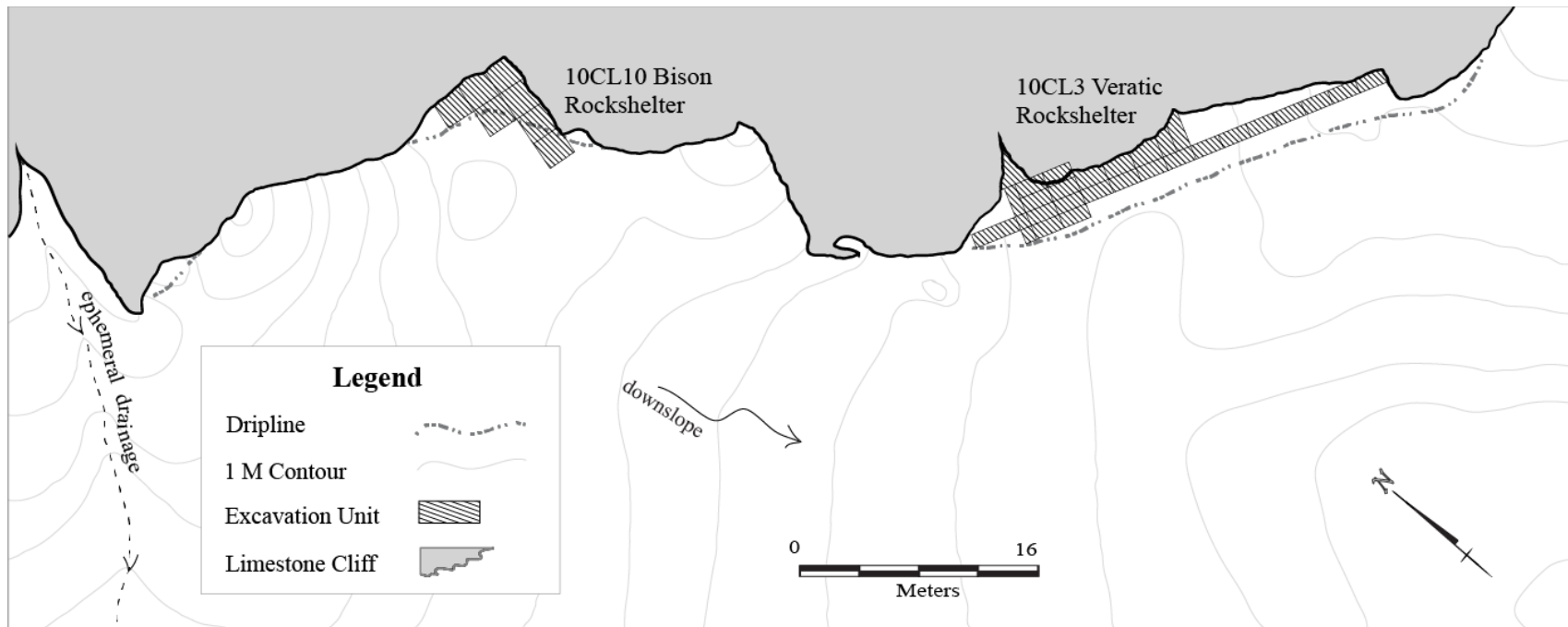


**Figure 0.1** Location of the Birch Creek Sites, 10CL3 and 10CL10.

## **Excavation History**

Swanson conducted his excavations of Bison and Veratic Rockshelters to support his contention that the Northern Shoshone were indigenous to their ethnographic range within Idaho (1972:5). This contention is at odds with Steward's (1938) ethnographic conclusions. Consequently, Swanson decided to investigate the origins of the Northern Shoshone at Birch Creek because an earlier 1958 investigation revealed the presence of at least two archaeological sites with substantially deep deposits.

Swanson's excavations began in 1960 at Veratic Rockshelter, selected for its stratigraphic depth. Swanson presumed that this depth would provide the lengthy cultural record needed to demonstrate a persistent Northern Shoshone presence. In order to determine the extent of cultural deposits, Swanson excavated a trench within Veratic Rockshelter. Next, Swanson tested Disappointment Cave (10CL9), with obvious results. Following a low artifact yield at Disappointment Cave, Swanson started excavation of Bison Rockshelter, which shares an alluvial fan with Veratic Rockshelter. Bison Rockshelter lies 28 m northwest of Veratic Rockshelter. Swanson concluded his excavations of Bison and Veratic Rockshelters by the end of 1961 field season. Swanson excavated both sites according to natural stratigraphic levels. At Veratic Rockshelter, Swanson laid out his excavation as grid of 28 1x2 m blocks. Swanson excavated Bison shelter with a roughly L-shaped group of seven 2x2 m blocks (Figure 5.2).



**Figure 0.2.** Excavation plan of the Birch Creek Site.

## Deposit Organization

In *Birch Creek* (1972), Swanson divides the occupational history of the Bison and Veratic Rockshelters into five culture phases and seven depositional periods. To define his culture phases, Swanson used a standard culture history approach based on projectile point typologies. He designated each phase with both a name and a Roman numeral designation. Swanson's depositional periods are defined according to predominant sediment type; these also received Roman numeral designations. Below, I summarize Swanson's reports of material recovered from each phase. I also report his best estimates of phase ages using conventional Georgian calendar dates, as Swanson did not tie his estimates to specific radiocarbon dates. I provide radiocarbon dates (Table 5.1) calibrated with OxCal 4.2 (Bronk Ramsey; Reimer et al. 2013) and the IntCal13 calibration curve, as reported by Keene (2016:3). Also included in Table 0-1 are dates from Byers (personal communication) and Swanson (1972), both calibrated with Calib 7.1 (Stuiver 2018) Following my summaries of each phase, I discuss the rockshelter's faunal material in its own section.

Swanson defined each of his depositional periods by predominant sediment type. He additionally divided each rockshelter's deposits into excavation levels (referred to as layers), which he defined according to geological stratigraphy. Swanson numbered these levels increasing with depth. The excavation level numbers overlap between the two shelters but do not signify the same deposits at both sites. Swanson's depositional periods and cultural phases, however, describe the same cultural and depositional

**Table 0-1** Radiocarbon Dates from Birch Creek (Byers personal communication; Keene 2016; Swanson 1972)

Reference, Lab Number	Phase	Level/Feature	Taxon	$\delta^{13}\text{C}$ (‰)	$^{14}\text{C}$ age year BP	95.4% (2 $\sigma$ ) cal age ranges	Area under distribution
(Keene 2016)							
UCIAMS-140280	Phase IV	Level 20	Artemisia cf. tridentata	$-147.19 \pm 0.0018$	$1280 \pm 20$	1180-1280	1
UCIAMS-140278b	Unassigned	Level 21	Artemisia cf. tridentata	$-43.3 \pm 0.0020$	$360 \pm 20$	320-490	1
UCIAMS-140281	Phase IV	Level 22	Artemisia cf. tridentata	$-228.24 \pm 0.0016$	$2080 \pm 20$	2000-2120	1
UCIAMS-140284	Phase III	Level 24	Artemisia cf. tridentata	$-310.4$	$2990 \pm 20$	3080-3220	1
UCIAMS-140276b	Unassigned	Level 25 top	Hardwood tree or shrub	$-22.93 \pm 0.0014$	$190 \pm 20$	modern-290	1
UCIAMS-140279b	Unassigned	Level 25	Artemisia cf. tridentata	$-40.68 \pm 0.0020$	$340 \pm 20$	320-470	1
UCIAMS-140274	Phase III	Level 26	Pseudotsuga menziesii	$-403.24 \pm 0.0014$	$4150 \pm 20$	4580-4820	1
UCIAMS-140272	Phase II	Level 27	Artemisia cf. tridentata	$-381.36 \pm 0.0014$	$3860 \pm 20$	4170-4410	1
UCIAMS-140275	Phase II	Level 27	cf. Juniperus sp.	$-400.85 \pm 0.0015$	$4120 \pm 20$	4570-4810	1
UCIAMS-140282	Phase II	Level 28	Artemisia cf. tridentata	$-487.96 \pm 0.0013$	$5380 \pm 20$	6030-6280	1
UCIAMS-140277	Phase II	Level 28	Artemisia cf. tridentata	$-514.22 \pm 0.0011$	$5800 \pm 20$	6540-6670	1
UCIAMS-140273	Phase II	Level 29	Pseudotsuga menziesii	$-482.74 \pm 0.0012$	$5300 \pm 20$	5990-6180	1
UCIAMS-140283b	Unassigned	Level 29	Artemisia cf. tridentata	$-40.31 \pm 0.0020$	$330 \pm 20$	310-460	1
UCIAMS-140271	Phase II	Feature 6	Pinus sp.	$-579.8 \pm 0.0012$	$6970 \pm 30$	7710-7860	1
Beta-331430	Phase II	Feature 6	“soft pine” (Pinus sp.)	$-22.9$	$7300 \pm 40$	8020-8180	1
UCIAMS-148190	Phase I	Level 30	unid.	$-653.5 \pm 0.0010$	$8520 \pm 30$	9490-9540	1
UCIAMS-140285b	Unassigned	Level 31	Artemisia cf. tridentata	$-384.98 \pm 0.0013$	$3910 \pm 20$	4260-4420	1
Beta-331431	Phase I	Level 31	“spruce”	$-23$	$8850 \pm 40$	9760-10,160	1
(Swanson 1972)							
UCLA-217	Phase IV	19-20	Bulk Charcoal?		$370 \pm 80$	290-540	0.99
UCLA-160	Phase IV	22	Bulk Charcoal?		$1580 \pm 80$	1310-1620	0.99
UCLA-218	Phase IV	26	Bulk Charcoal?		$2920 \pm 120$	2840-3360	0.97
WSU-502	Phase IV	27	Bulk Charcoal?		$4000 \pm 470$	3330-5640	>0.99
I-452	Phase IV	29	Bulk Charcoal?		$4500 \pm 170$	4810-5590	0.98
UCLA-162	Phase IV	29	Bulk Charcoal?		$5670 \pm 120$	6270-6740	0.99
UCLA-161	Phase IV	29	Bulk Charcoal?		$5870 \pm 120$	6410-6980	1
WSU-503	Phase II	Feature 6	Bulk Charcoal?		$6030 \pm 190$	6450-7310	1
TBN-3042	Phase II	Feature 6	Bulk Charcoal?		$6280 \pm 230$	6650-7590	1
WSU-760a	Phase I	30	Bone Collagen		$10,340 \pm 830$	9600-13,790	1
(Byers personal communication)							
ACRF-3616	Phase V	Level 1	Bison		$410 \pm 30$	330-520	1
ACRF-3619	Phase V	Level 2	Bison		$260 \pm 30$	150-430	0.99
ACRF-3624	Phase V	Feature 6	Bison		$460 \pm 30$	480-540	1
ACRF-3629	Phase V	Level 3	Bison		$380 \pm 30$	320-510	1
ACRF-3640	Phase IV	Level 4-6	Bison		$2140 \pm 40$	2000-2310	1
ACRF-3642	Phase IV	Level 5	Bison		$1280 \pm 30$	1180-1290	1
ACRF-3653	Phase IV	Level 7	Bison		$2020 \pm 30$	1890-2050	1
ACRF-3658	Phase IV	Level 15	Bison		$2900 \pm 30$	2950-3160	1
ACRF-3659	Phase III	Level 16	Bison		$2940 \pm 30$	2990-3180	0.99
ACRF-3660	Phase III	Level 17	Bison		$3770 \pm 30$	4,010-4,240	0.99
ACRF-3657	Phase IV	Level 9-13	Bison		$3460 \pm 30$	3640-3830	1
ACRF-3664	Phase II	Level 28	Bison		$4590 \pm 30$	5070-5450	1
ACRF-3665	Phase I	Level 32	Medium Artiodactyl		$8250 \pm 40$	9090-9400	0.99

Note: Byers (personal communication) and Swanson (1972) dates calibrated with Calib 7.1 (Stuiver 2018); Keene (2016) dates calibrated with OxCal (Bronk Ramsey 2009; Reimer et al. 2013)



phenomena at both Bison and Veratic Rockshelters. As such, I describe the contents of both rockshelters jointly.

Gallup's (1960) appendix to *Birch Creek* describes the depositional context of the Birch Creek rockshelters. Both lie on stratified fans formed from alluvial and colluvial debris at the feet of overhanging limestone cliffs. Bison Rockshelter is in a more favorable position for the aggregation of sediments, thusly it lies on a higher fan and contains thicker strata. Both rockshelters contain very angular gravel within all strata with the exception of Level 33 at Bison Rockshelter. Bison Rockshelter's Level 33 gravels are sub-angular or slightly rounded. The sediments from both rockshelters were moderately calcareous. Gallup (1960) described each level's sediments at both sites; I include these descriptions within Tables 5.2 through 5.6, which also serve to summarize which excavation levels are present in each cultural phase and depositional period. I briefly describe each depositional period alongside my descriptions of the cultural material that formerly lay within the two rockshelters' sediments. Below, I briefly describe each cultural phase, as defined by Swanson (1972), from oldest to youngest and specify the excavation levels that contributed each phase's materials.

### Birch Creek Phase

Swanson (1972) placed The Birch Creek Phase (Phase I) between 9000 to 5200 BC. This phase post-dates Depositional Period I, which contained no cultural material. Keene's (2016:3) work produced an early  $^{14}\text{C}$  date of  $9950 \pm 200$  cal yr BP and a late date of 9090-9400 cal yr BP (Table 5.1). The Birch Creek Phase represents the earliest cultural material at the Birch Creek sites. It consists of excavation levels 30 (159-189

**Table 0-2** Veratic Rockshelter Strata.

Phase	Depositional Period	Layer	Depth	Deposition Description	Sediment Description
V	VII	1		Upper Dung Layer	Dung
V	VII	2		Upper Dung Layer	Dung
V	VII	3		Upper Dung Layer	Dung
V	VII	4		Upper Dung Layer	Dung
V	VII	5		Upper Dung Layer	Dung
V	VII	6		Upper Dung Layer	Dung
V	VII	7		Upper Dung Layer	Dung
V	VII	8		Upper Dung Layer	Dung
V	VII	9	4-11	Dung	Grayish-brown (10YR 5/2); very dark brown (10YR 2/2); gritty loam; weak medium platy structure; few fine tubular pores; in the part of the pit sampled, mixed with dung.
V	VII	10	-	Dung	Thin dung layer too thin to sample.
V	VII	11	11-13	Dung	Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) loam; weak fine platy structure; pores absent.
V	VII	12	13-15	Dung	Dark grayish-brown (10YR 4/2); very dark brown (10YR 2/2) loam, very high in organic matter; weak fine platy structure; weakly calcareous; few fine tubular pores.
V	VII	13	15-18	Dung	Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) loam; moderate fine platy structure; bits of charcoal common; includes thin layer high in organic matter that is about 1 unit in value darker than matrix.
V	VII	14	18-19	Dung	Very dark gray (10YR 3/1); weak fine platy structure; weakly calcareous except for thin line layer at boundary between levels 14 and 15.
V	VII	15	19-23	Dung	Very dark grayish-brown (10YR 3/2); very dark brown (10YR 2/2) slightly gravelly loam; massive.
V	VII	16	23-25	Dung	Very dark grayish-brown (10YR 3/2); very dark brown (10YR 2/2) loam, high in organic matter; massive; weakly calcareous.
V	VII	17	25-28	Dung	Dark grayish-brown (10YR 4/2); very dark grayish-brown (10YR 3/2) slightly gravelly loam; weak fine platy structure.
V	VII	18	28-30	Dung	Dark grayish-brown (10YR 4/2); very dark brown (10YR 2/2) gravelly loam; massive.
V	VII	-	30-34		A discontinuous layer within level 18 is gravelly loam about one unit lighter than the remainder of the level.
IV	VI	19	34-37	Rockfall III	Grayish-brown (10 YR 5/2); very dark grayish-brown (10YR 3/2) gravelly sandy loam; single grain.
IV	VI	20	absent	Rockfall III	
IV	V	Feature 1	37-50		Dark grayish-brown (10YR 4/2); very dark brown (10YR 2/2) very gravelly sandy loam; single grain; this layer is a fire pit with large amount of charcoal, wood, and bone, includes layers of gravelly loam.
IV	V	21	absent	Yellow Silt with some Rockfall	Very dark grayish-brown (10YR 3/2) very gravelly sandy loam, single grain.
IV	V	22	50-54	Yellow Silt with some Rockfall	Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) very gravelly loam; massive; gravel is finer than in other horizons.

**Table 0-3 Veratic Rockshelter Strata Continued.**

Phase	Depositional Period	Layer	Depth	Deposition Description	Sediment Description
IV	V	Feature 2	54-70		Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) gravelly loam; massive; highly calcareous; this layer is a fire pit with numerous charcoal, wood, and bone fragments.
IV	V	23	absent	Yellow Silt with some	
IV					
III	V	24	70-73	Yellow Silt with some Rockfall	Light brownish-gray (10YR 6/2); dark grayish-brown (10YR 4/2) very gravelly sandy loam; single grain.
III	V	25	73-84	Silt	Light brownish-gray (10YR 6/2); dark grayish-brown (10YR 4/2) extremely gravelly sandy loam; single grain; thin lime coating on gravel.
III	IV	26	84-98	Silt	Pale-brown (10YR 6/3); dark brown (10YR 4/3) extremely gravelly coarse sandy loam; single grain.
II	IV	27	98-105	Rockfall II	Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) gravelly sandy loam; single grain; with few bits of charcoal.
II	IV	Feature 4		Silt	
II	IV	28 (F4)	105-107	Rockfall II	Pale-brown (10YR 6/3); brown (10YR 4/3) slightly gravelly loam; massive.
II	IV	29	107-141	Rockfall II	Light brownish-gray (10YR 6/2); grayish-brown (10YR 4/2) gravelly loam with several darker layers having numerous bits of charcoal.
II	IV	29 Feature 11			
II	IV	29 Feature 5			
	IV				
II	III	29 Feature 6			
II	III	Feature 6		Silt	
II	III	Feature 6a	141-151		Pale-brown (10YR 6/3); brown (10YR 5/3) slightly gravelly fine sandy loam; massive; common bits of charcoal.
II	III	Feature 6b1	151-154		Very pale-brown (10YR 8/3); pale-brown (10YR 6/3) fine sand; weak very fine platy structure, with many fine tubular pores, weakly calcareous; this layer is volcanic ash showing evidence of occupation.
II	III	Feature 6b2	154-159		White (10YR 8/1); light-gray (10YR 7/1) fine sand; weak very fine platy structure; few fine tubular pores; weakly calcareous; this is volcanic ash showing no alteration from occupation.
I	II	30	159-189	Rockfall I	Light brownish-gray (10YR 6/2); dark grayish-brown (10YR 4/2) gravelly loam; massive.
I	II	31	189-200	Stream Sands and Gravels	Light gray (10YR 7/1); gray (2.5Y 5/1) sandy loam massive.
I	II	32		Stream Sands and Gravels	
		Feature 102			

**Table 0-4 Bison Rockshelter Strata.**

Phase	Depositional Period	Layer	Depth	Description	Sediment Description
		Surface	0-53	Dung	
V	VI	1		Loam	
V	VI	1a	53-59	Loam	Dark-gray (10YR 4/1); Very dark-brown (10YR 2/2) slightly gravelly loam; moderate fine platy structure; with a mixture of lighter colored material that is dark gray (10 YR 4/1) when moist.
V	VI	1b	59-61	Loam	Dark grayish-brown (10YR 4/2) ; very dark brown (10YR42/2) loam, high in organic matter; weak medium sub-angular blocky structure.
V	VI	2		Loam	
V	VI	2a	61-66	Loam	Grayish-brown (10YR 5/2); dark grayish-brown (10YR 4/2) slightly gravelly loam; very weak fine platy structure; includes some darker material that is very dark-brown (10YR 2/2) when moist.
V	VI	3a		Rockfall III	
V	VI	3a1	66-71	Rockfall III	Grayish-brown (10YR 5/2); dark grayish-brown (10YR 4/2) slightly gravelly loam, very weak, fine granular structure; many bone and charcoal fragments.
V	VI	3a2	71-74	Rockfall III	Similar to 3a1 but has more gravel and sand and fewer fragments of bone and charcoal.
V	VI	3b	74-79	Rockfall III	Very dark- grayish brown (10YR 3/2); very dark brown (10YR 2/2) slightly gravelly loam; with thin layers of blk (10YR 2/1) material, numerous fragments of bone and charcoal.
V	VI	3c	79-102	Rockfall III	Grayish- (10YR 5/2); dark grayish-brown (10 YR 4/2) slightly gravelly loam, with thin strata that are gravelly loam.
V	VI				
V	V	4	102-112	Yellow Sandy Loam II	Pale-brown (10YR 6/3); dark brown (10YR 4/3) loam, approaching clay loam; numerous charcoal fragments.
V					
IV	V	5	112-117	Yellow Sandy Loam II	Dark grayish-brown (10YR 4/2); very dark grayish-brown (10YR 3/2) slightly gravelly loam; numerous charcoal fragments.
IV	V	6	117-124	Yellow Sandy Loam II	Pale-brown (10YR 6/3); dark brown (10YR 4/3) loam, approaching clay loam.
IV	V	7	124-132	Yellow Sandy Loam II	Dark grayish-brown (10YR 4/2); very dark grayish-brown (10YR 3/2) slightly gravelly loam; numerous charcoal, wood, and bone fragments.
IV	V	8	See Sediment description	Yellow Sandy Loam II	Absent in sampled portion.
IV	V	9	132-145	Yellow Sandy Loam II	Brown (10YR 5/3); dark brown (10YR 4/3) gravelly sandy loam, approaching loam; with thin strata of very gravelly sandy loam.
IV	V	10	145-147	Yellow Sandy Loam II	Light brownish-gray (10YR 6/2); dark grayish-brown (10YR 4/2) slightly gravelly loam; common fragmentsw of charcoal.
IV	V	11	147-150	Yellow Sandy Loam II	Pale-brown (10YR 6/3); dark brown (10YR 4/3) clay loam, approaching loam; few fine lime veins; highly calcareous.
IV	V	11 to 13		Yellow Sandy Loam II	
IV	V	12	150-152	Yellow Sandy Loam II	Dark-gray (10YR 4/1); black (10YR 2/1) slightly gravelly loam.
IV	V	13	152-155	Yellow Sandy Loam II	Brown (10YR 5/3); dark brown (10YR 4/3) slightly gravelly loam, with numerous sand grains; highly calcareous.
IV	V	13		Yellow Sandy Loam II	
IV	V	14	155-162	Yellow Sandy Loam II	Dark-gray (10YR 4/1); black (10YR 2/1) gravelly loam; numerous charcoal fragments.
IV	V	15	162-168	Yellow Sandy Loam II	Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) gravelly clay loam, approaching loam; highly calcareous.

**Table 0-5 Bison Rockshelter Strata Continued.**

Phase	Depositional Period	Layer	Depth	Description	Sediment Description
III	V	16		Yellow Sandy Loam II	
III	V	16a	168-175	Yellow Sandy Loam II	Dark-gray (10YR 4/1); black (10YR 2/1) gravelly loam.
III	V	16b	168-175	Yellow Sandy Loam II	Dark-gray (10YR 4/1); black (10YR 2/1) gravelly loam.
II	IV	17		Rockfall II	
II	IV	17a	175-188	Rockfall II	Pale-brown (10YR 6/3); brown (10YR 5/3) extremely gravelly loam, highly calcareous.
II	IV	17b	175-188	Rockfall II	Pale-brown (10YR 6/3); brown (10YR 5/3) extremely gravelly loam, highly calcareous.
II	IV	17c	188-200	Rockfall II	Pale-brown (10YR 6/3); brown (10YR 5/3) extremely gravelly loam with much fine, angular gravel, highly calcareous.
II	IV	17d	200-238	Rockfall II	Pale-brown (10YR 6/3); brown (10YR 5/3) extremely gravelly sandy loam with coarse, angular gravel, highly calcareous.
II	III	18	238-246	Yellow Sandy Loam I	Very pale-brown (10YR/7/3); grayish-brown (2.5Y 5/3) slightly gravelly loam; this horizon on the opposite side of the pit has very little gravel.
II	III	19	246-248	Yellow Sandy Loam I	Light-gray (10YR/ 7/2); grayish-brown (2.5Y 5/2) coarse sandy loam, highly calcareous.
II	III	20a	248-251	Yellow Sandy Loam I	Light brownish-gray (2.5Y 6/3); very dark grayish-brown (2.5 Y 3/2) clay loam, weakly laminated.
II	III	20b	251-254	Yellow Sandy Loam I	Light gray (2.5 Y 7/3); grayish-brown (2.5Y 5/3) clay loam approaching loam; with few fine lime veins, weakly laminated.
II	III	20c	254-255	Yellow Sandy Loam I	Grayish-brown (2.5Y 5/3); very dark grayish-brown (2.5Y 3/2) clay loam, weakly laminated; the portion of the pit sampled has a thicker dark colored occupational layer than the opposite wall.
II	III	21a	255-259	Yellow Sandy Loam I	Light brownish-gray (2.5Y 6/3); grayish-brown (2.5Y 5/3) clay loam common thin lime veins, weakly laminated; this layer appears to be due to stratification of darker material from source area rather than occupation.
II	III	21b	259-264	Yellow Sandy Loam I	Very pale-brown (10YR 7/3); light brownish-gray (10YR 6/3) clay loam, weakly laminated.
II	III	22	264-274	Yellow Sandy Loam I	Light brownish-gray (2.5Y 6/3); grayish-brown (2.5Y 5/3) slightly gravelly loam, approaching clay loam; common fine lime veins.
II	III	23	274-277	Yellow Sandy Loam I	Light brownish-gray (2.5Y 6/3); grayish-brown (2.5Y 5/3) loam approaching clay loam; few fine lime veins.
II	III	24	277-280	Yellow Sandy Loam I	Grayish-brown (10YR 5/2); very dark grayish-brown (10YR 3/2) and grayish-brown (2.5Y 5/3) slightly gravelly loam approaching clay loam; common fine lime veins.
II	III	25	280-286	Yellow Sandy Loam I	Light brownish-gray (2.5Y 6/3); grayish-brown (2.5Y 5/3) clay loam, approaching loam.
II	III	26	Absent, see description	Yellow Sandy Loam I	Dark grayish-brown (10YR 4/2); very dark brown (10YR 2/2) loam.

**Table 0-6 Bison Rockshelter Strata Continued.**

Phase	Depositional Period	Layer	Depth	Description	Sediment Description
II	III	27	286-296	Yellow Sandy Loam I	Light brownish-gray (2.5 Y 6/2); grayish-brown (2.5Y 5/2) slightly gravelly loam, few fine lime veins.
II	III	28a	296-304	Yellow Sandy Loam I	Pale-brown (10YR 6/3); brown (10YR 5/3) clay loam, approaching loam, common fine lime veins.
II	III	28b	304-306	Yellow Sandy Loam I	Light brownish-gray (10YR 6/2); dark grayish-brown (10YR 4/2) in places is dark brown (10YR 2/2); slightly gravelly clay loam approaching loam; common fine lime veins.
II	III	29a	306-311	Yellow Sandy Loam I	Very pale-brown (10YR 7/3); brown (10YR 5/3) clay loam approaching loam; common fine lime veins.
II	III	29b	311-316	Yellow Sandy Loam I	Very pale-brown (10YR 7/3); brown (10YR 5/3) slightly gravelly loam, common medium lime veins.
II	III	29c	316-319	Yellow Sandy Loam I	Very pale-brown (10YR 7/3); brown (10YR 5/3) clay loam approaching loam; few fine lime veins.
II	III	29d	319-328	Yellow Sandy Loam I	Dark brownish-brown (10YR 4/2); very dark-brown (10YR 2/2) loam, approaching clay loam; common medium lime veins.
II	III	29e	328-332	Yellow Sandy Loam I	Pale-brown (10YR 6/3); dark-brown (10 YR 4/3) loam approaching clay lam; common medium lime veins.
II	III	29f	332-345	Yellow Sandy Loam I	Dark grayish-brown (10YR 4/2); very dark-brown (10YR 2/2) slightly gravelly loam; few fine lime veins.
II	III	29g	345-356	Yellow Sandy Loam I	Pale-brown (10YR 6/3); brown (10YR 5/3) fine sandy loam; few fine lime veins.
II	III	29h	356-367	Yellow Sandy Loam I	Dark grayish-brown (10YR 4/2); very dark-brown (10YR 2/2) fine sandy loam approaching loam; common medium lime veins.
II	III	29i	367-370	Yellow Sandy Loam I	Pale-brown (10YR 6/3); dark-brown (10YR 4/3) loam; few fine lime veins.
II	III	29j	370-373	Yellow Sandy Loam I	Pale-brown (10YR 6/3); dark brown (10YR 4/3) slightly gravelly loam; common fine lime veins.
II	III	29k	373-388	Yellow Sandy Loam I	Very pale-brown (10YR 6/3); brown (10YR 5/3) loam; common fine lime veins.
II	III	29l	388-396	Yellow Sandy Loam I	Light brownish-gray (10YR 6/2); dark grayish-brown (10YR 4/2) slightly gravelly loam; few fine lime veins.
II	III	29m	396-410	Yellow Sandy Loam I	Very pale-brown (10YR 7/3); brown (10YR 5/3) loam; common fine lime veins.
I	II	30a	410-417	Rockfall I	Very pale-brown (10YR 7/3) brown (10YR 5/3) gravelly loam.
I	II	30b	417-421	Rockfall I	Very Pale-brown (10YR 7/3); brown (10YR 5/3) very gravelly sandy loam.
I	II	30c	421-430	Rockfall I	Very Pale-brown (10YR 7/3); brown (10YR 5/3) slightly gravelly loam.
I	II	30d	430-438	Rockfall I	Very Pale-brown (10YR 7/3); brown (10YR 5/3) gravelly coarse, sandy loam.
I	II	31a	438-444	Rockfall I	Very pale-brown (10YR 7/3); brown (10YR 5/3) fine sand, the upper part of a volcanic ash layer.
I	II	31b	444-448	Rockfall I	White (10yr 8/2); light-gray (10YR 7/2) fine sand; the lower portion of the volcanic ash layer, unaltered and non-calcareous.
I	II	32a	448-471	Rockfall I	Very pale-brown (10YR 7/3); brown (10YR 5/3) gravelly loam.
I	II	32b	471-484	Rockfall I	Very Pale-brown (10YR 7/3); brown (10YR 5/3) very gravelly sandy loam.
I	I	32c	484-578	Sheet Flood	Very pale-brown (10 YR 7/3); brown (10YR 5/3) very gravelly loam.
I	I	33	578-620	Stream Sands and Gravels	Light-gray (2.5Y 6/1); dark-gray (2.5Y 4/1) gravelly loamy sand; the gravel in the the 33 levels is somewhat rounded and was probably deposited by Birch Creek.
I	I	33a	620-640	Stream Sands and Gravels	Light-gray (2.5Y 6/1); dark-gray (2.5Y 4/1) loamy sand with occasional rounded gravel.
I	I	33b	640-660	Stream Sands and Gravels	Light brownish-gray (2.5Y 6/2); dark grayish-brown (2.5Y 4/2) gravelly loamy sand; gravel is more rounded than in levels 33 and 33a.
I	I	34	660	Stream Sands and Gravels	Limestone bedrock.

cm) and 31 (189-200 cm) in 10CL3 and levels 30 (410-438 cm), 31 (438-448 cm), and 32 (448-578 cm) in site 10CL10.

All of the Birch Creek Phase lies within sediments of Depositional Period II. Depositional Period II sediments are primarily composed of roof fall, as well as Mt. Mazama and Glacier Peak Volcanic Ash (Keene 2016; Swanson 1972). According to Swanson (1972), the Birch Creek occupation corresponds to a long-term transition from arid conditions to cool and moist conditions, followed by a warming trend. Swanson notes that Bison Rockshelter had a higher occupancy than did Veratic Rockshelter during the Birch Creek Phase.

Swanson recovered several lithic artifacts from Birch Creek Phase deposits. These include Birch Creek Points, defined as lanceolate points with lateral flakes that feather across the midline, resulting in a ridgeless cross-section. Swanson recovered 10 such points from Veratic Rockshelter, and one from Bison Rockshelter (Swanson 1972). Swanson (1972) recovered ten artifacts, which he terms either scrapers or fleshers from Veratic rockshelter, while Bison Rockshelter yielded five scrapers from the Birch Creek Phase. I summarize these lithics, and those of the other phases in Table 5.7.

### Bitterroot Phase

Swanson named the next oldest phase the Bitterroot Phase (Phase II), which he places between 5200 and 1450 BC. The oldest radiocarbon date for the Bitterroot Phase is 8020-8180 cal yr BP, while the youngest is 4170-4410 cal yr BP (Keene 2016:3). 10CL3 Phase II material came from levels 27 (98-105 cm), 28 (105-107 cm), and 29 (107-141 cm), and Feature 6 (141-159 cm). 10CL10 material lies in levels 17 (175-238

**Table 0-7. Lithics from Birch Creek.**

Category	Type	10CL3 - Veratic Rockshelter									10CL10 - Bison Rockshelter							Birch Creek Total				
		Phase									Phase							Phase				
		Birch Creek 1a	Birch Creek 1b	Birch Creek Phase Total	Bitterroot	Beaverhead	Blue Dome	Lemhi	Total	Birch Creek	Bitterroo t	Beaverhead	Blue Dome	Lemhi	Total	Birch Creek	Bitterroot	Beaverhead	Blue Dome	Lemhi	Total	
Lanceolate	Birch Creek	7	14	21	11	5			37	1	1				2	22	12	5	0	0	39	
	Plainview-McKean	2	3	5	2				7						0	5	2	0	0	0	7	
	Triangular			0	3				3		1			1	2	0	4	0	0	1	5	
	Broad Round-Based	1		1					1						0	1	0	0	0	0	1	
	Ovate Tanged-Based			0					0		1			1	2	0	1	0	0	1	2	
	Parallel Sided, Round Based			0					0				1		1	0	0	0	1	0	1	
	Large, Thick-Shouldered			0					0		1				1	0	1	0	0	0	1	
Side-Notched	Lanceolate Total	10	17	27	16	5	0	48	1	4	0	1	2	8	28	20	5	1	2	56		
	Beaverhead			0	39	3	12		54		2		11	20	33	0	41	3	23	20	87	
	Bitterroot	2	3	5	94	9	7		115		3				3	5	97	9	7	0	118	
	Blue Dome			0		1	3		4				4		4	0	0	1	7	0	8	
	Desert Plains			0					0					22	22	0	0	0	0	22	22	
Stemmed	Side-Notched Total	2	3	5	133	13	22	0	173	0	5	0	15	42	62	5	138	13	37	42	235	
	Alberta/Silver Lake	1		1					1						0	1	0	0	0	0	1	
	Stemmed, Indented-base		1	1	13	10	4		28						0	1	13	10	4	0	28	
	Stemmed Total	1	1	2	13	10	4	0	29	0	0	0	0	0	2	13	10	4	0	0	29	
	Broad		1	1		5	14		20		3		19		22	1	3	5	33	0	42	
Corner-Notched	Sharply Barbed		1	1	2	2	26		31		1	2	11		14	1	3	4	37	0	45	
	Elko Eared		3	3	21	8	1		33				3	3	6	3	21	8	4	3	39	
	Elko Corner-Notched			0		1	1		2					1	1	0	0	1	1	1	3	
	Broad, Single Barbed			0					0			1			1	0	0	1	0	0	1	
	Basal-Notched			0					0				1		1	0	0	0	1	0	1	
	Corner-Notched Total	0	5	5	23	16	42	0	86	0	4	3	34	4	45	5	27	19	76	4	131	
	Point Total	13	26	39	185	44	68	0	336	1	13	3	50	48	115	40	198	47	118	48	451	
Scrapers and Fleshers	Total			35	109	34	21		199	6	16	2	13	15	52	41	125	36	34	15	251	
Ground Stone	Manos				5	4			9					1	1	0	5	4	0	1	10	
	Milling Stone								0		1				1	0	1	0	0	0	1	
	Milling Stone Fragment			1	5				6						0	1	5	0	0	0	6	
	Total	0	0	1	10	4	0	0	15	0	1	0	0	1	2	1	11	4	0	1	17	
Total		39	78	154	684	174	225	0	1237	9	57	11	163	161	401	163	741	185	388	161	1638	



cm), 18 (238-246 cm), 19 (246-248 cm), 20 (248-255 cm), 21 (255-264 cm), 22 (264-274 cm), 23 (274-277 cm), 24 (277-280 cm), 25 (280-286 cm), 26 (absent in sequence description), 27 (286-296 cm), 28 (296-306 cm) through 29 (306-396 cm) (Gallup 1960; Swanson 1972).

Together, Depositional Periods III and IV span the Bitterroot Phase. Swanson states that the early Bitterroot (Depositional Period III) pattern corresponds to Altithermal conditions, while the later Bitterroot (Period IV) represents cooler, moister conditions. Depositional Period III consists of alternating layers of yellow eolian silt and fine gravel (Swanson 1972). Depositional Period IV consists of coarsely packed medium to coarse gravel.

Notable lithics recovered from the Bitterroot Phase include 188 projectile points and 125 scrapers (Swanson 1972). A slim majority of the phase's projectile points are the eponymous Bitterroot Side-notched point, which Swanson describes as appearing lenticular in cross section and having straight edges that feel serrated from uniform, flat, bifacial pressure flaking. The vast majority of the projectile points (175) came from Veratic Rockshelter. These include 11 Birch Creek Points, two Plainview-McKean Points, three triangular lanceolate points, 39 Beaverhead Preform Points, 94 Bitterroot Side-Notched, 13 stemmed, indented-base points, two sharply barbed corner-notched points, and 21 Elko Eared Points. Bison Rockshelter contributed far fewer points (13). These consist of one Birch Creek Point, one large triangular lanceolate point, one ovate, tanged-based point, one large, thick-shouldered point, two Beaverhead Preform Points, three Bitterroot Side-notched Points, three broad, corner-notched points, and a single sharply barbed, corner-notched point. Of the scrapers, 109 came from Veratic, and 16

were recovered from Bison. Six manos and five milling stone fragments were also present within the Bitterroot Phase, all groundstone, save a single mano, came from Veratic.

### Beaverhead Phase

Swanson (1972) suggests that Birch Creek's next phase, the Beaverhead Phase (Phase III), spans the period from 1450 to 950 BC. The oldest radiocarbon date available from the Beaverhead Phase is 4580-4820 cal yr BP, while the most recent is 2990-3180 cal yr BP (Keene 2016:3). Beaverhead Phase material came from between the uppermost level (26) of Depositional Period IV and the lower portion of Period V (Swanson 1972). At Veratic, Beaverhead material came from levels 24 (70-73 cm), 25 (73-84 cm), and 26 (84-98 cm). Swanson collected Bison Rockshelter's Beaverhead material from between levels 15 (168-175 cm) and 16 (168-175 cm). Swanson discovered all of Bison Rockshelter's Beaverhead Phase material within Depositional Period V, which consists of fine to medium gravel and yellow brown sandy loam (Gallup 1960; Swanson 1972).

The Beaverhead Phase lithic material includes a number of projectile points of various styles (Swanson 1972). The majority come from 10CL10, which contributes five lanceolate points, 13 side-notched points, 10 stemmed points, five broad corner notched points, two sharply barbed corner notched points, eight Elko eared points and a single Elko corner-notched point (Swanson 1972). Site 10CL10 contained far fewer projectile points, in this case, producing two sharply barbed corner-notched points, and one broad single-barbed corner-notched point (Swanson 1972). The Beaverhead Phase contains a

number of scrapers as well (Swanson 1972). Two of the scrapers are from 10CL10, while 33 are from 10CL3 (Swanson 1972).

### Blue Dome Phase

Swanson (1972) labeled the second most recent phase Blue Dome (Phase IV) and placed it between 950 BC and AD 1250. The earliest Blue Dome radiocarbon date is 3640-3830 cal yr BP (Byers personal communication). The most recent Blue Dome radiocarbon date is 1180-1280 cal yr BP (Keene 2016:3). The Blue Dome component of 10CL3 includes levels 18 (28-34 cm), 19 (34-37 cm); Feature 1 (37-50 cm) 20 (absent in sequence description), 21 (absent sequence description), 22 (50-54 cm); Feature 2 (54-70 cm) through 23 (absent in sequence description). Swanson placed layers 18 through 20 within Depositional Period V. Layers 21 through 23 and Features 1 and 2 lie within Depositional Period VI. Depositional Period VI consists mainly of fine to medium gravel, brown sand, and silt. Depositional Period V consists of yellow sandy loam, with fine to medium sized gravel. Yellow to yellow-brown sheet flood deposits are present within Depositional Period V. 10CL10 Blue Dome Phase material comes from levels 5 (112-117 cm), 6 (117-124 cm), 7 (124-132 cm), 8 (absent in sequence description), 9 (132-145 cm), 10 ( through 15, all of which lie within Depositional Period V.

Projectile points recovered from site 10CL10's Blue Dome Phase include a single lanceolate point, 11 Beaverhead preform points, 4 Blue Dome side-notched points, 19 broad corner-notched points, 11 sharply barbed corner-notched points, 1 basally corner-notched point, and 3 Elko Eared Points (Swanson 1972). Eleven scrapers were recovered from 10CL10's Blue Dome Phase (Swanson 1972). Blue Dome Phase lithics recovered

from 10CL3 include 12 Beaverhead preforms, 7 Bitterroot side-notched points, 3 Blue Dome side-notched points, 4 stemmed indented-based points, 14 broad corner notched points, 26 sharply barbed corner notched points, 1 Elko corner notched point, and 21 scrapers (Swanson 1972).

### Lemhi Phase

The most recent Birch Creek phase, Lemhi (Phase V), Swanson dated to between AD 1250 and 1850 (Swanson 1972). Unfortunately, Swanson based his age estimate solely on point typology, since he had no radiocarbon dates for this phase. Byers's (personal communication) work produced a number of radiocarbon dates from levels attributed to Lemhi, the earliest is 480-540 cal yr BP, the latest date is 150-430 cal yr BP. The 10CL3 Lemhi Phase material comes from levels 1 through 18, while the 10CL10 artifacts come from levels 1 through 4. Swanson recovered 10CL3 Lemhi Phase cultural material from Depositional Periods VI and VII. Depositional Period VII sediments are modern dung, and include gravel, glass, and wire nails (Swanson 1972). The 10CL10 material comes from the uppermost portion of Depositional Period V and Depositional Period VI sediments.

The lithics recovered from the Lemhi Phase are less numerous than those from the other phases. 10CL3 contained only a few debitage specimens, while 10CL10 yielded 15 scrapers, two lanceolate points, 20 Beaverhead preform points, 22 desert plains side-notched points, three Elko eared points, and one Elko corner-notched point (Swanson 1972).

## **Fauna**

As my research relies upon Birch Creek's faunal remains, I discuss them here rather than alongside my summaries of the rockshelter's phases. By covering faunal material in this section, I can discuss trends in their composition more holistically. Swanson's (1972) Birch Creek excavations yielded many faunal remains. While Swanson did not exhaustively identify the faunal assemblage, he did report Minimum Number of Individuals (MNI) and Number of Identifiable Specimens (NISP) counts for many of the present fauna. Swanson generated phase MNI values for bison and for the total of elk, deer, sheep, and pronghorn by summing MNI values from each phase's constituent excavation levels. As I use the phase as my finest level of analysis in this paper, I report the highest MNI that Swanson (1972) provides for any level within each phase (Table 5.8). My more conservative MNI values thus represent Swanson's identification efforts but avoid his potential MNI aggregation errors. While Swanson's results differ dramatically from mine, I do not discuss these disagreements here. Instead, I discuss these inconsistencies in Chapter 6, Discussion. Here, I relay Swanson's findings and attempt to identify trends in the assemblage. I discuss the fauna from each phase in turn, and provide graphs to provide illustration when appropriate.

Artiodactyls dominate the Birch Creek Phase faunal remains available for study today. Swanson reported that approximately half of these artiodactyl specimens are bison remains (NISP 10, MNI 3), while the majority of the remainder (NISP 13, MNI 3) are sheep (NISP 12, MNI 2) (Swanson 1972). Single pronghorn and Idaho pygmy rabbit

**Table 0-8** Fauna reported by Swanson.

Taxon	I		II		III		IV		V	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
Bison	10	3	44	4	160	12	472	18	555	20
Cervus			1	1	1	1				
Antilocapra	1	1	24	4	6	2	7	4	6	2
Odocoileus			12	3	5	4	31	6	28	6
Centrocercus			55	22	1	1				
Lagomorph	1	1	9	4	11	5	14	6	8	6

(*Sylvilagus idahoensis*) specimens round out the assemblage of prey animals present in the Birch Creek Phase (Swanson 1972).

The Bitterroot Phase faunal remains are, again, primarily those of artiodactyls, in this case, bighorn sheep (NISP 145, MNI 7) (Swanson 1972). However, the introduction of sage grouse and an increase in lagomorph (NISP 14, MNI 6) representation cause a substantial drop in the proportion of the diet composed of artiodactyls (Swanson 1972).

Bighorn sheep (NISP 145, MNI 7) dominate the Bitterroot Phase artiodactyl assemblage, as reported by Swanson (1972). Bison (NISP 44, MNI 4) represent the second most common artiodactyl recovered from the Bitterroot Phase. Swanson neglects to provide an MNI for sage grouse (NISP 55). However, as he reports the recovery of 43 sage grouse humeri, I consider an MNI of 22 reasonable.

According to Swanson's numbers, the Beaverhead Phase represents a turning point in the subsistence strategy pursued by Birch Creek's inhabitants. For the first time, bison (NISP 160, MNI 12) represent the most common taxon present by MNI; indeed, they outnumber all medium-sized artiodactyls combined (Swanson 1972). A single sage grouse specimen recovered from Depositional Period V represents the last contribution of sage grouse to the Birch Creek fauna (Swanson 1972). Sheep (NISP 60, MNI 4), the previous most common taxa, fall to second place in the Beaverhead Phase, after which

they continue to decline in importance, though they remain the most common medium-sized artiodactyl (Swanson 1972).

The faunal remains present in the Blue Dome Phase include a far higher proportion of bison (NISP 472, MNI 18) than do the previous phases (Swanson 1972). Elk (NISP 2 MNI 1) make a nominal contribution to the Blue Dome assemblage. Medium-sized artiodactyls account for approximately 17 percent of the Blue Dome faunal assemblage (Swanson 1972). Sheep (NISP 59, MNI 6), deer (NISP 31, MNI 6), pronghorn (NISP 7, MNI 4), and comprise the medium artiodactyls present in the Blue Dome Phase, and show the same general pattern of importance seen in earlier phases (Swanson 1972). Lagomorphs contribute the remaining 2 percent of the edible fauna present (Swanson 1972).

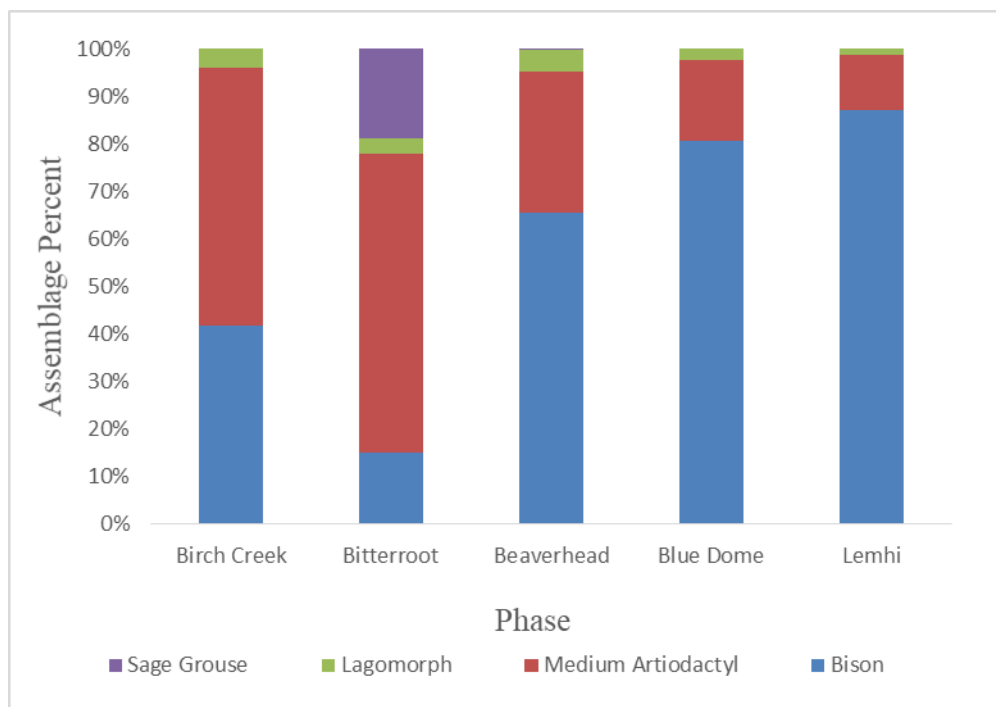
The faunal remains from the Lemhi Phase are similar in composition to those from the Blue Dome. Bison (NISP 555, MNI 20) contribute approximately 87 percent of specimens from this phase, medium-sized artiodactyls contribute 12 percent of the assemblage, and lagomorphs (NISP 8, MNI 6) make up just over one percent of the Phase's NISP (Swanson 1972). Swanson reports bighorn sheep (NISP 41, MNI 6), and deer (NISP 28, MNI 6) in roughly equal abundance, while pronghorn (NISP 6, MNI 2) are less common.

While Swanson's cataloging efforts were incomplete, they do allow for the identification of certain trends. Most notably, the appearance of sage grouse within the Bitterroot Phase, coupled with the dip in bison abundance and the expansion of lagomorph presence within the same phase, suggests a possible episode of resource depression during the Bitterroot Phase. Figure 5.3 illustrates this episode of low-rank

resource usage. Figure 5.6 documents the drop in the Artiodactyl Index that occurred during this phase. When one graphs the Artiodactyl Index by depositional period (Figure 5.6), the effect of sage grouse inclusion becomes clearer (Depositional Period IV corresponds to the latter portion of the Bitterroot Phase). The prey model predicts that the inclusion of a low-ranked item, such as sage grouse should accompany a relative shortage of high ranked game. Moreover, Figure 5.4 shows a substantial drop in the Bison Index concurrent with grouse inclusion.

Unfortunately, investigation of a possible resource depression episode requires information unavailable from the existing literature about Birch Creek. I address these shortcomings through further identification executed according to the methods detailed in Chapter 3, and through consideration of the effects of the independent variables presented in Chapter 4. My identification efforts yielded not only an increased NISP for most taxa present at Birch Creek, but also provided data on processing behavior and prey age structure, all of which allow me to further investigate the possibility of anthropogenic resource depression. Chapter 6, Results fully presents this information. The independent variables, including Bryson and Bryson's (2000) centennial-scale archaeoclimate model, and a summed probability distribution of radiocarbon dates, illuminate external drivers of prey abundance. However, before presenting my results, I outline the Birch Creek faunal assemblage's shortcomings below.

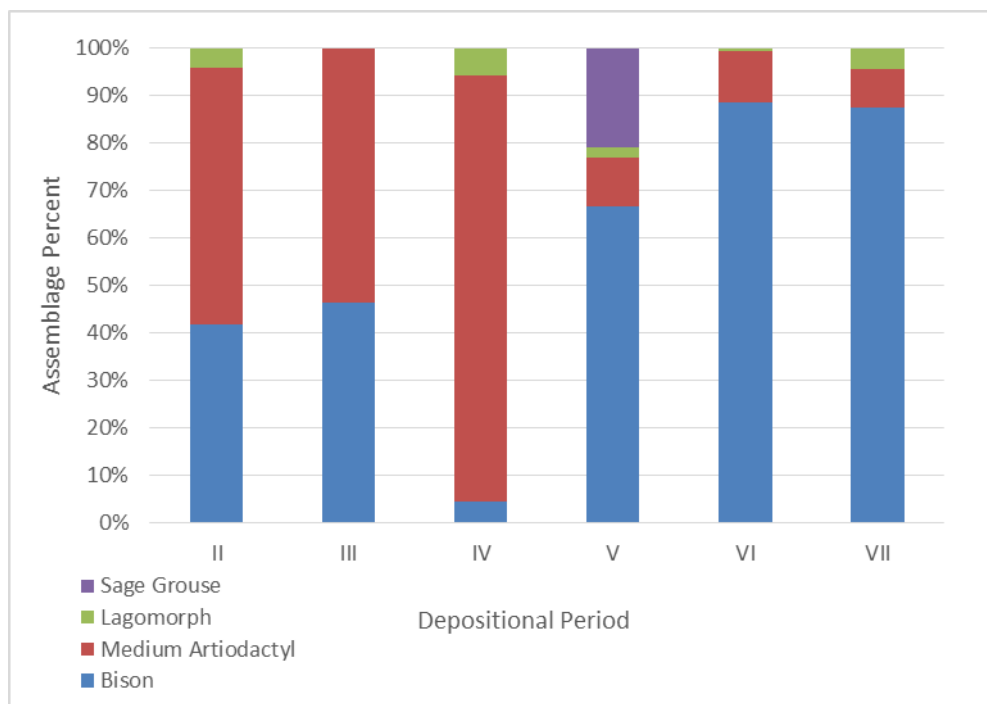




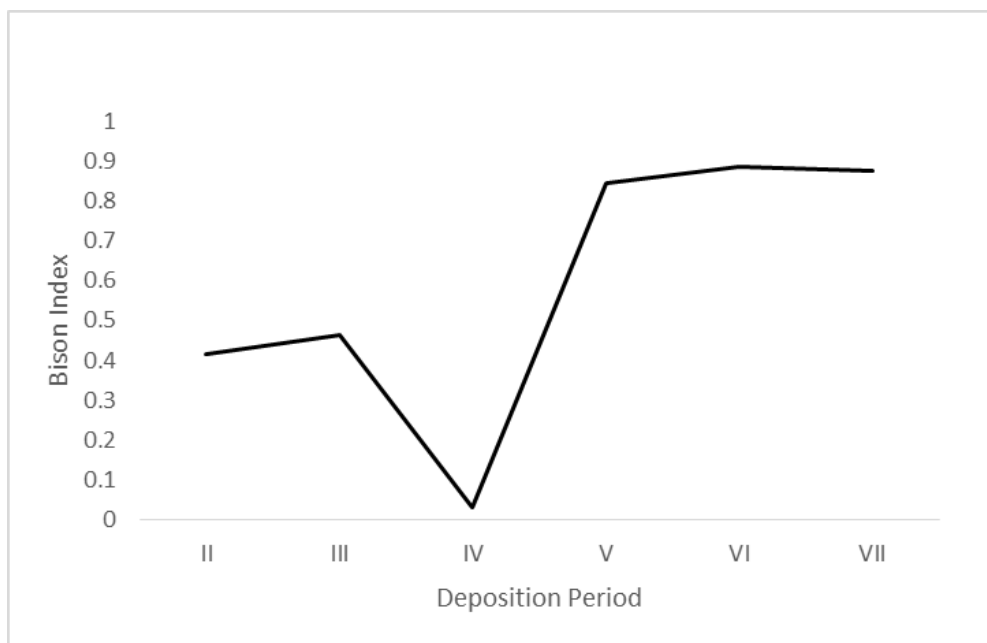
**Figure 0.3.** Composition of prey taxa by phase as presented in Swanson (1972).



**Figure 0.4.** The Bison Index as a proportion of the prey assemblages presented in Swanson (1972) by phase.



**Figure 0.5.** Composition of prey taxa by Depositional Period as presented in Swanson (1972).



**Figure 0.6.** The Bison Index as a proportion of the prey assemblages presented in Swanson (1972) by Depositional Period

## Collection Biases

The Birch Creek archaeofauna provides a far from perfect collection for archaeological inquiry. Initial inspection suggests that the collection suffers from several biases, unclear excavation methods, and uncertain provenience of specimens. I discuss these shortcomings in turn below.

### Excavation and Curation Biases

Unfortunately, Swanson's collection methods leave much to be desired by modern standards. Much of the Birch Creek bone was discarded at some point prior to the present day. At Bison Rockshelter, Swanson's original catalogs included 2087 specimens recorded as some sort of faunal remain; 671 (32%) of those specimens are marked as discarded. At Veratic Rockshelter, Swanson appears to have excavated, collected, and then discarded even more specimens. In this instance, 2304 of the 5023 (46%) specimens met this fate. Most likely, these discarded specimens represent highly fragmentary pieces of bone that the original excavators felt to lack any diagnostic (to species or element) value. However, archaeologists know today that fragmentary specimens, especially those from long bones can provide important information on carcass use and processing intensity.

Providing additional confusion is the fact that Swanson recorded many retained specimens in the same manner ("large bone fragment") as discarded specimens. As I successfully identified the vast majority of skeletal fragments to element, this makes a blanket assumption that discarded specimens represent unidentifiable fragments a

dubious contention. Furthermore, I have no way of estimating which specimens, if any, Swanson discarded during excavation, and thus went entirely unrecorded. This uncertainty only increases as *Birch Creek* makes only passing mention of screening, and fails to mention mesh size or whether excavators consistently screened deposits. These uncertain curation methods make the detection of changes to processing intensity less certain, as I cannot know whether Swanson ever recorded small bone fragments resulting from fat extraction in any form.

### Provenience Issues

The Birch Creek archaeofauna suffers from multiple unclear proveniencing practices. Swanson's original catalog assigns many specimens within the Birch Creek archaeofauna to extremely vague vertical proveniences. Such proveniences include the like of "combination dirt and gravel layer," "Brown gravel layers," and "from level below yellow brown layer." These vague proveniences meant that I could not assign such specimens to phases, and represent lost dataset robusticity. Fortunately, these completely unclear proveniences represent a small minority of the collection's recorded proveniences.

Less problematic, but also worrying is the issue of proveniences recorded with depth. Specimens thus provenienced often prove difficult to assign to phase. Gallup's (1960) soil descriptions, included as an appendix to *Birch Creek*, somewhat ameliorates this problem. His guide lists the depths (calculated from ground surface) at which each excavation level was encountered in Block 11 of Veratic Rockshelter, and across the whole of Bison Rockshelter. Unfortunately, as the excavation levels vary somewhat

horizontally, the depth listed on a specific artifact does not necessarily correspond to the same level as that which Gallup listed within the soil description appendix. Furthermore, many of the depths listed for individual specimens are measured from specific datums that are not documented in either the Idaho Museum of Natural History (IMNH) artifact catalog or Swanson's (1972) Birch Creek volume.

To address this problem, I produced conversion factors by comparing the listed depth below datum and depth below surface included within the IMNH artifact catalog. I include these conversions within Tables 5.2 through 5.6, which relate Phase, Depositional Period, Level, and Depth in both sites.

## **Summary**

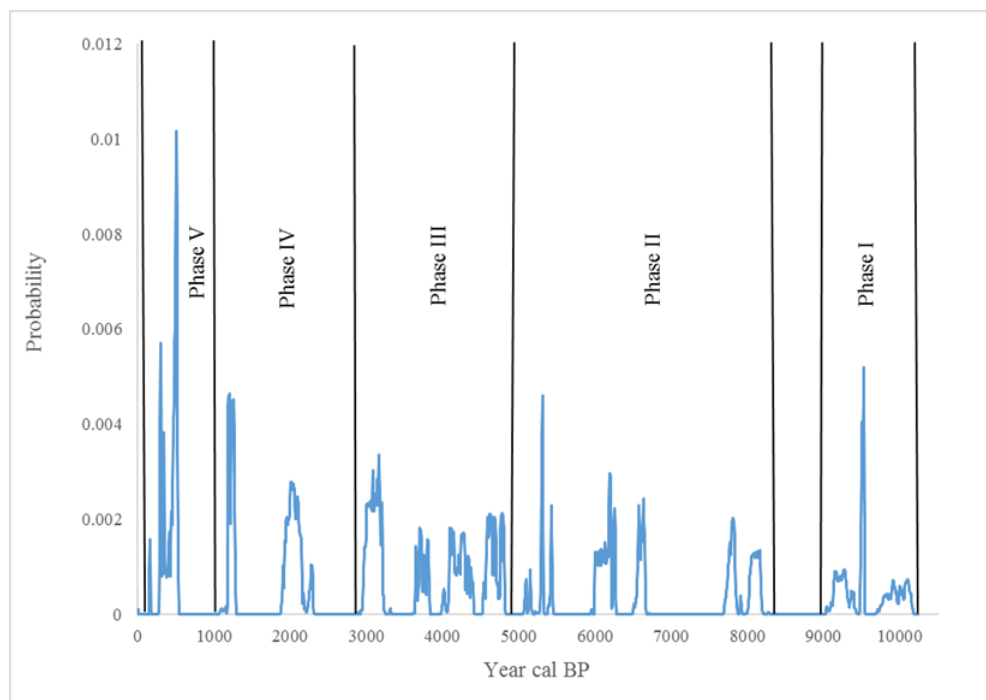
Swanson's excavations and study Bison and Veratic Rockshelters yielded imperfect, but usable, archaeofaunal collections with which I will test my hypotheses about the effects of prey population attributes and human hunting. While Swanson's excavation provided an extensive faunal collection with an extensive time span, the collection has drawbacks as well. The collection's chief drawback is its lack of many of the fragmentary remains collected by Swanson. Its second drawback lies in the unclear way that some of its specimens were provenienced. The results of my own identification efforts, and the extent to which the Birch Creek archaeofauna proved to be consistent with expectations derived from the independent variables in Chapter 4, I discuss in Chapter 6, Results.

## RESULTS

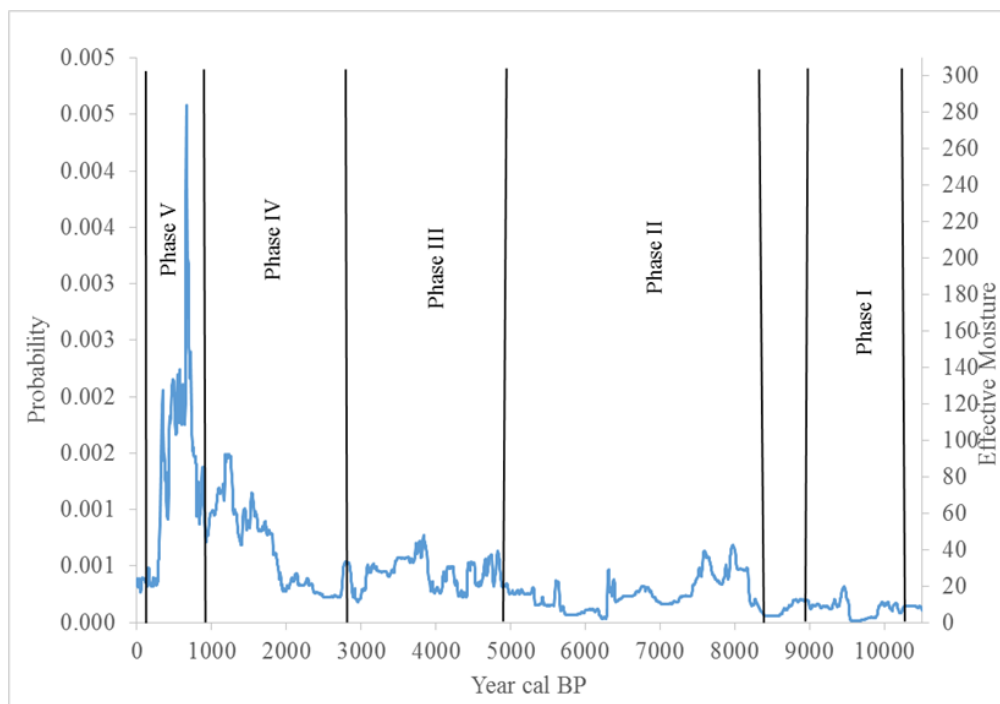
In Chapter 6, I use the FPE and prey models described in Chapter 2, Theoretical Background, to guide predictions about the relationships between the Birch Creek fauna and the environmental data presented in Chapter 4, Independent Variables. Below, Table 6.1 summarizes these environmental conditions, while Figures 6.1, 6.2, and 6.3 graphically depict the Idaho and Birch Creek radiocarbon SPD's, modeled effective moisture, and the time spans covered by each of Birch Creek's phases. I make predictions specific to both the FPE model and the prey model about prey composition, prey abundance, and processing intensity. This allows me to investigate whether consideration of prey reproduction rates permits improved prediction of the archaeological record compared to a model that makes no such consideration.

**Table 0-1** – Summary of Environmental Conditions

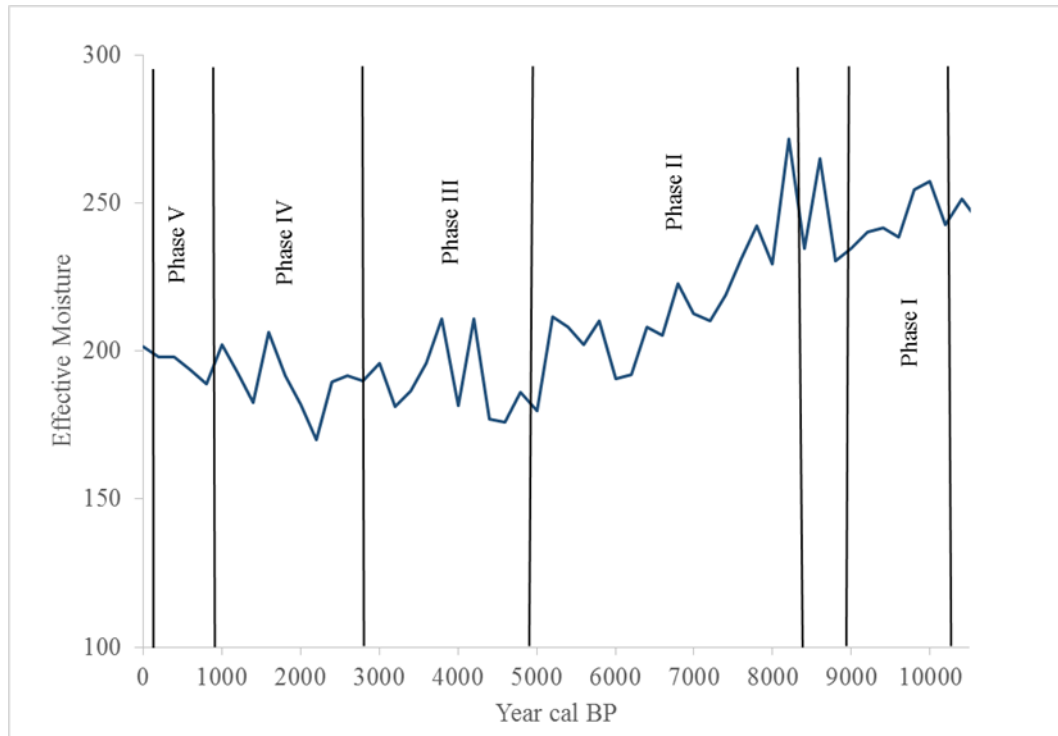
Phase	Age BP	Average Effective Moisture	Average Summed Probability
I	10245-9000	244.19	0.000120046
II	8345-4955	215.66	0.00025488
III	4955-2955	189.23	0.000443274
IV	2955-1170	189.25	0.000567223
V	645-150	196.56	0.001286865



**Figure 0.1.** The radiocarbon SPD's from Birch Creek, Idaho (Byers personal communication; Keene 2016).



**Figure 0.2** Idaho Radiocarbon SPD with demarcations indicated for the Birch Creek phases (Byers personal communication).



**Figure 0.3** An archaeoclimate model for effective moisture with phase demarcations.

## Expectations

Below, I outline predictions for correlations between the Birch Creek archaeofauna and modeled average annual effective moisture and average summed radiocarbon probability (SPD) values. I first detail the predictions based upon the assumptions of the prey model only. Next, I detail predictions based upon the assumptions of the FPE, which differ from those of the prey model in their consideration of prey reproductive rates.

Both increased demand and decreased supply can reduce net acquisition rate (NAR) of any scarce resource. According to the assumptions of the prey model, low return prey only enter the diet when access to high-ranked prey is sparse enough that the



addition of such lower-ranked prey increases NAR (Bayham 1979; Charnov 1976; Charnov and Orians 1973; Emlen 1966; MacArthur and Pianka 1966; Schoener 1971; Stephens and Krebs 1986). Below, I model contexts where such circumstances might be expected. Here, I use each phase's average SPD value as a proxy for both demand (hunting pressure), while I use modeled effective moisture as a proxy measure of supply (game abundances). Following this assumption, I expect the abundance of high-ranked prey, such as bison, and the next highest-ranked prey, medium-sized artiodactyls, to decline as SPD increases, and as effective annual moisture decreases. I also expect ScoreMature values, the relative abundances of young vs old prey individuals, to decline as SPD increases, and as effective annual moisture decreases. Since bison are the highest ranked prey on the SRP and high-ranked prey should be targeted whenever encountered, I expect the depression of local bison populations before other prey. As reduced average population age can indicate top-down resource depression (see Chapter 4), I expect bison to be consistently younger than other prey, more frequently exhibiting unfused and partially fused bones than smaller artiodactyls. I would also expect medium-sized prey (deer, pronghorn, and bighorn sheep) to exhibit population depression before small game, but since the Birch Creek collection generally lacks appropriate small-bodied prey specimens, I was unable to test this prediction. Lastly, I expect the foragers occupying the Birch Creek shelters to expend more effort processing prey when it is less common. In this case, when SPD increases, and as effective annual moisture decreases, prey should be less available and processing should intensify.

While the FPE model makes very similar predictions to the prey model, its scope is greater in one important area. The FPE model considers the intrinsic reproductive rate

of prey to be an important factor in the effects of hunting pressure (Winterhalder and Lu 1997). When using prey model assumptions, I would expect degree of prey population depression to increase with prey rank. When considering the assumptions of the FPE model, I would expect prey of equal or higher rank and lower rate of intrinsic increase to exhibit lower ScoreMature and a more frequent incidence of unfused and incompletely fused bones regardless of environmental conditions.

### **Resource Depression**

As detailed earlier, the FPE model predicts that hunting pressure results in top-down resource depression, mediated by prey rank and reproductive rate. Within this context, mean prey age can monitor top-down induced resource depression (Anderson 1981; Broughton 1994, 1997, 2002; Caughley 1966, 1977; Klein and Cruz-Urbe 1984; Lyman 1987), as discussed in Chapter 3. Here, I present ScoreMature values graphically alongside environmental conditions in Figures 6.4 through 6.9. I plot ScoreMature values against average effective moisture and SPD in Figures 6.10 through 6.15. Tables 6.2 through 6.7 provide comprehensive mammalian bone fusion data for each Birch Creek phase. I present environmental data in Chapter 4. A set of statistical analyses intended to detect trends in prey maturity follow these figures and tables.

### **Maturity and Environment**

In this section, I document the covariance of ScoreMature and my two environmental conditions, SPD and average effective moisture. So that I may link each

phase with its corresponding environmental conditions, I average the SPD and effective moisture values for each phase's two standard deviation range of radiocarbon years cal BP and use these averages as x values that I can relate to the ScoreMature values, which I enter as y values. I evaluate this relationship separately for the following taxa: all artiodactyls, bison, and all medium-sized artiodactyls. I provide date ranges and summarize average conditions for each phase in Table 6.1, while the raw data are available in Chapter 4. As predicted, I expect to see prey age negatively correlate with hunting pressure, as estimated by SPD. Furthermore, I expect to see a stronger negative correlation between SPD and ScoreMature for high ranked, slower reproducing bison than I do between SPD and the ScoreMature of lower-ranked, quicker reproducing medium-sized artiodactyls.

### Maturity and Summed Radiocarbon Probability

The relationships between ScoreMature and my independent variables generally failed to follow my expectations. The ScoreMature for bison did not correlate with SPD ( $r_s = 0.4$ ,  $p = 0.50$ ). This result contradicts my expectation that Bison ScoreMature would negatively correlate with human population density. I have some misgivings with this result, as the phase (I) with the youngest bison population consists of a very small assemblage (NISP 19, MNI 2). Phase I contains both fully-fused and unfused elements and may represent a cow and calf taken together. In any case, I do not consider the Phase I assemblage likely to represent the general age of bison on the landscape. However, omitting Phase I from my analysis nonetheless fails to find a significant correlation between Bison ScoreMature and SPD ( $r_s = -0.2$ ,  $p = 0.8$ ). Furthermore, the ScoreMature

of all artiodactyls does not significantly correlate with SPD ( $r_s = -0.6, p = 0.28$ ), although the relationship runs in the right direction. While this result contradicts my expectation that prey age would decrease with hunting pressure, the lack of significant correlation may well result from the small sample sizes in play. Finally, ScoreMature calculated from all medium-sized artiodactyls fails to correlate with SPD ( $r_s = -0.5, p = 0.39$ ).

### Maturity and Effective Moisture

Contrary to the expectations of both the FPE and the prey models, ScoreMature failed to correlate significantly with average annual effective moisture, regardless of which taxon was used. The ScoreMature of bison correlates negatively, but not significantly, with effective moisture ( $r_s = -0.8, p = 0.10$ ). This means that despite the negative relationship between moisture and Bison ScoreMature, the relationship is not robust enough to reject random chance as the possible cause at  $p = .05$ , although small sample sizes likely conspire to limit statistical significance and . For the reasons given in the previous section, I also determined Spearman's rank correlation coefficient for Bison ScoreMature and effective moisture, disregarding Phase I. However, even when disregarding Phase I, Bison ScoreMature does not correlate significantly with effective moisture ( $r_s = -0.6, p = 0.4$ ). Similar to Bison ScoreMature, All Artiodactyl and Medium-sized Artiodactyl ScoreMature do not correlate significantly with average annual effective moisture ( $r_s = -0.2, p = 0.75$  and  $r_s = 0.7, p = 0.19$  respectively).

**Table 0-2.** Phase I Mammal Age Data.

Taxon	Fusion 0	Fusion 1	Fusion 2	Fusion 3	Fusion 4	Fusion 5	Fetal
Bison	4	1	0	2	0	12	0
Ovis	0	0	0	8	6	15	0
Antilocapra	0	0	0	5	2	6	0
Unidentified Medium Bovidae	0	0	0	0	1	6	0
Odocoileus	0	0	0	0	0	3	0
Unidentified Medium Artiodactyls	1	0	0	1	3	2	0
Unidentified Medium Mammals	0	0	0	0	1	1	0
Small Mammals	2	0	0	7	3	9	0
Unidentified Artiodactyls	0	0	0	0	0	1	0
Total	7	1	0	23	16	55	0

**Table 0-3.**Phase II Mammal Age Data.

Taxon	Fusion 0	Fusion 1	Fusion 2	Fusion 3	Fusion 4	Fusion 5	Fetal
Bison	9	1	3	16	8	63	2
Cervus	0	0	0	0	0	1	0
Large Unidentified Artiodactyls	0	0	0	0	0	1	0
Antilocapra	5	0	4	59	22	84	0
Ovis	5	1	0	46	33	102	0
Medium Unidentified Bovids	4	0	2	30	21	41	0
Odocoileus	0	0	0	2	0	13	0
Medium Unidentified Artiodactyls	17	1	0	34	38	41	0
Canis	2	0	0	11	1	19	0
Medium Unidentified Canidae	0	0	0	1	0	0	0
Medium Unidentified Carnivores	1	0	0	1	0	0	0
Medium Unidentified Mammals	0	0	0	2	2	8	0
Small Unidentified Canids	0	0	0	1	0	0	0
Small Unidentified Carnivores	0	0	0	1	0	3	0
Lepus	0	0	0	1	3	3	0
Sylvilagus	0	0	0	0	0	2	0
Unidentified Leporids	0	0	0	0	0	0	0
Unidentified Rodents	0	0	0	0	0	3	0
Small Unidentified Mammals	4	1	0	15	7	6	0
Unidentified Artiodactyls	0	0	0	0	1	10	1
Unidentified Mammals	1	0	0	1	3	6	2
Total	48	4	9	221	139	406	5

**Table 0-4.** Phase III Mammal Age Data.

Taxon	Fusion 0	Fusion 1	Fusion 2	Fusion 3	Fusion 4	Fusion 5	Fetal
Bison	10	1	5	23	13	43	1
Ovis	1	0	0	7	4	22	0
Antilocapra	3	0	2	18	9	34	0
Odocoileus	0	0	0	0	0	1	0
Medium Unidentified Bovids	7	0	0	28	7	8	0
Unidentified Medium Artiodactyls	2	0	0	1	4	9	0
Canis	2	0	0	7	1	27	0
Lynx	0	0	0	0	0	1	0
Unidentified Medium Felids	0	0	1	0	0	1	0
Unidentified Medium Carnivores	0	0	0	1	0	2	0
Unidentified Medium Mammals	1	0	0	0	6	14	0
Lepus	0	0	0	1	1	0	0
Sylvilagus	0	0	0	1	0	9	0
Rodentia	0	0	0	0	0	1	0
Small Unidentified Mammals	3	0	0	9	2	4	0
Unidentified Mammals	1	0	0	0	2	0	1
Total	30	1	8	96	49	176	2

**Table 0-5.** Phase IV Mammal Age Data.

Taxon	Fusion 0	Fusion 1	Fusion 2	Fusion 3	Fusion 4	Fusion 5	Fetal
Bison	90	8	16	218	60	255	5
Unidentified Large Artiodactyls	1	0	0	0	0	2	0
Unidentified Large Mammals	0	0	0	0	0	1	0
Ovis	2	0	1	7	3	50	0
Antilocapra	0	0	2	32	6	33	0
Unidentified Medium Bovids	1	0	1	12	6	19	0
Odocoileus	0	0	0	1	2	22	0
Unidentified Medium Artiodactyls	3	1	0	7	5	35	0
Canis	2	0	0	16	5	20	0
Unidentified Medium Canids	0	0	0	0	0	1	0
Unidentified Medium Carnivores	0	0	0	1	1	2	0
Unidentified Medium Mammals	1	0	0	2	3	2	0
Vulpes	0	0	0	0	0	1	0
Unidentified Small Canids	0	0	0	2	0	0	0
Unidentified Small Carnivores	0	0	0	2	0	0	0
Lepus	0	0	0	0	0	2	0
Sylvilagus	0	0	0	0	0	5	0
Unidentified leporids	0	0	0	1	0	4	0
Peromyscus	0	0	0	0	0	1	0
Unidentified Rodents	1	0	0	0	0	2	0
Unidentified Small Mammals	6	0	0	8	2	8	0
Unidentified Mammals	1	0	0	0	2	8	1
Total	108	9	20	309	95	473	6

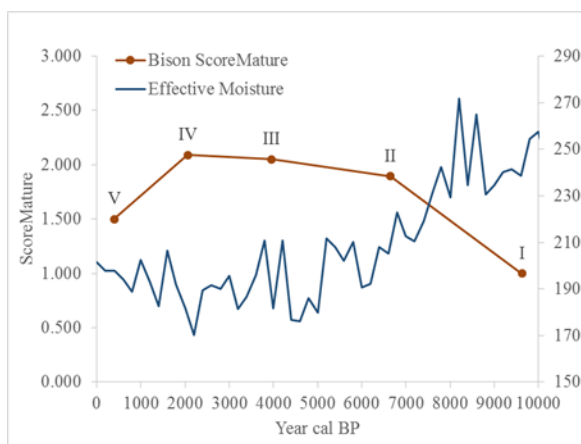
**Table 0-6.** Phase IV Mammal Age Data.

Taxon	Fusion 0	Fusion 1	Fusion 2	Fusion 3	Fusion 4	Fusion 5	Fetal
Bison	90	8	16	218	60	255	5
Unidentified Large Artiodactyls	1	0	0	0	0	2	0
Unidentified Large Mammals	0	0	0	0	0	1	0
Ovis	2	0	1	7	3	50	0
Antilocapra	0	0	2	32	6	33	0
Unidentified Medium Bovids	1	0	1	12	6	19	0
Odocoileus	0	0	0	1	2	22	0
Unidentified Medium Artiodactyls	3	1	0	7	5	35	0
Canis	2	0	0	16	5	20	0
Unidentified Medium Canids	0	0	0	0	0	1	0
Unidentified Medium Carnivores	0	0	0	1	1	2	0
Unidentified Medium Mammals	1	0	0	2	3	2	0
Vulpes	0	0	0	0	0	1	0
Unidentified Small Canids	0	0	0	2	0	0	0
Unidentified Small Carnivores	0	0	0	2	0	0	0
Lepus	0	0	0	0	0	2	0
Sylvilagus	0	0	0	0	0	5	0
Unidentified leporids	0	0	0	1	0	4	0
Peromyscus	0	0	0	0	0	1	0
Unidentified Rodents	1	0	0	0	0	2	0
Unidentified Small Mammals	6	0	0	8	2	8	0
Unidentified Mammals	1	0	0	0	2	8	1
Total	108	9	20	309	95	473	6

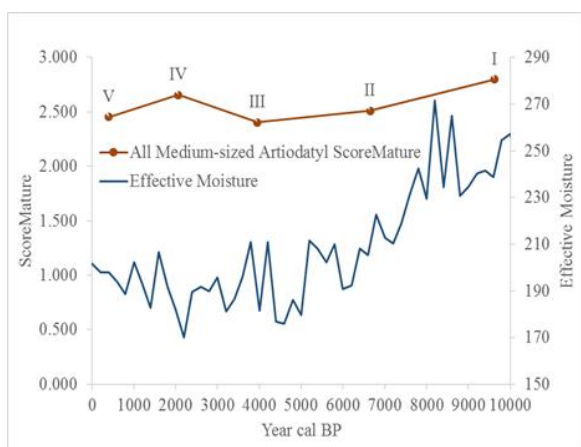


**Table 0-7.** Phase V Mammal Age Data.

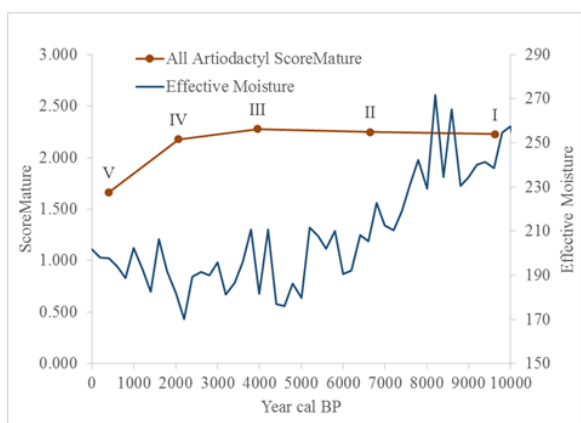
Taxon	Fusion 0	Fusion 1	Fusion 2	Fusion 3	Fusion 4	Fusion 5	Fetal
Bison	134	20	28	134	61	394	25
Large Unidentified Bovids	0	0	0	0	0	1	0
Large Unidentified Artiodactyls	0	0	0	0	0	8	0
Large Unidentified Mammals	0	0	0	0	0	1	0
Antilocapra	1	0	2	17	3	25	0
Ovis	0	0	0	15	3	40	0
Unidentified Medium Bovids	1	0	0	5	1	13	0
Odocoileus	3	0	2	2	0	33	0
Unidentified Medium Artiodactyls	3	0	0	11	7	29	1
Canis	4	0	0	24	4	27	0
Lynx	0	0	0	0	0	1	0
Unidentified Medium Carnivores	0	0	0	0	0	1	0
Unidentified Medium Mammals	0	0	0	0	1	6	0
Lepus	0	0	0	0	0	2	0
Sylvilagus	0	0	0	0	0	5	0
Citellus	0	0	0	0	0	3	0
Unidentified Rodents	0	0	0	0	0	2	0
Small Unidentified Mammals	0	0	0	1	0	7	0
Unidentified Artiodactyls	0	0	0	0	0	4	0
Total	146	20	32	209	80	603	26



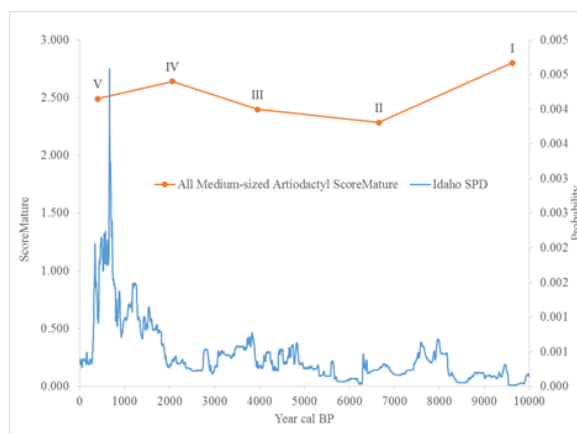
**Figure 0.4.** Bison ScoreMature plotted against modeled effective moisture.



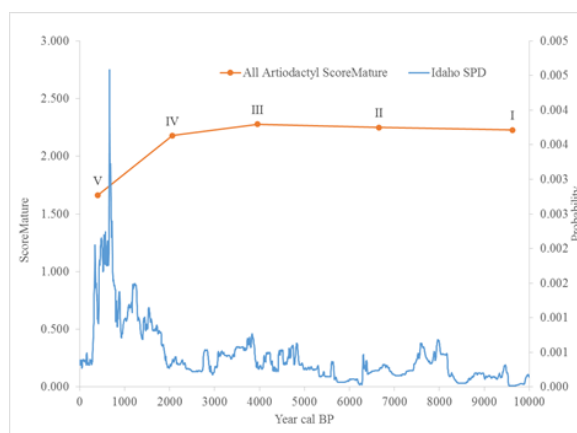
**Figure 0.5.** ScoreMature of all medium-sized artiodactyls plotted against modeled effective moisture.



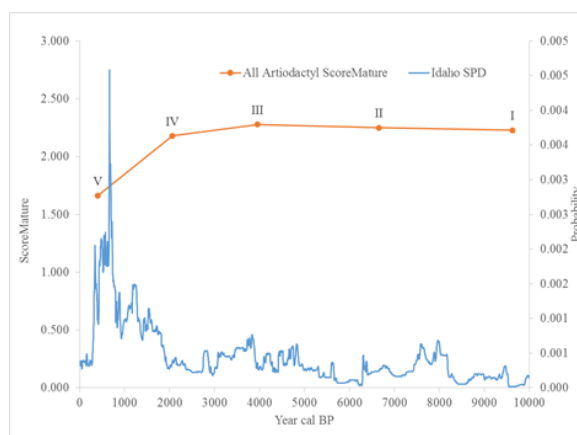
**Figure 0.6.** All artiodactyl ScoreMature plotted against modeled effective moisture.



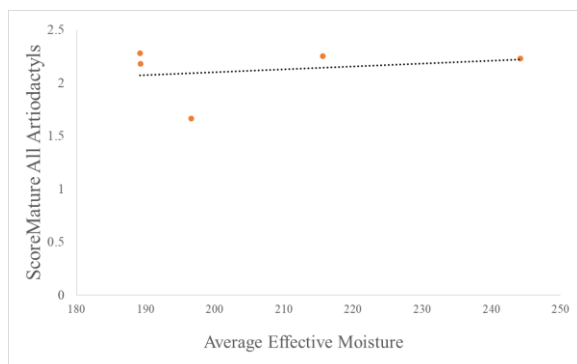
**Figure 0.7.** ScoreMature of all medium-sized artiodactyls plotted against summed radiocarbon probability.



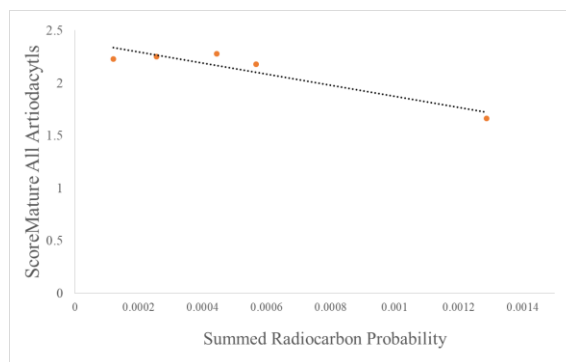
**Figure 0.8.** ScoreMature of all artiodactyls plotted against summed radiocarbon probability.



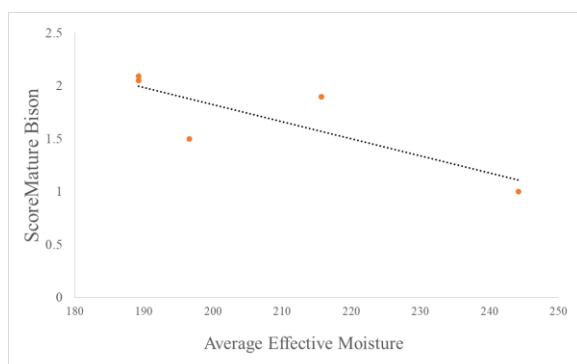
**Figure 0.9.** Bison ScoreMature plotted against summed radiocarbon probability.



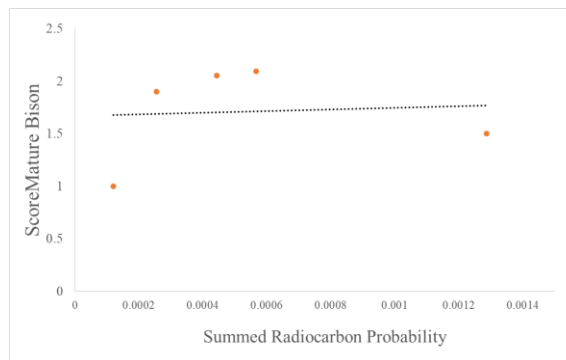
**Figure 0.10.** ScoreMature All Artiodactyls plotted against modeled average effective moisture.



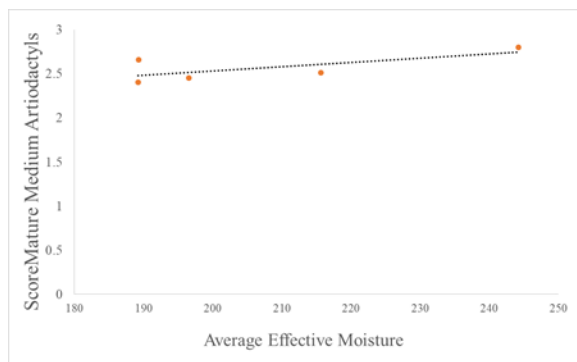
**Figure 0.13.** ScoreMature All Artiodactyls plotted against summed radiocarbon probability.



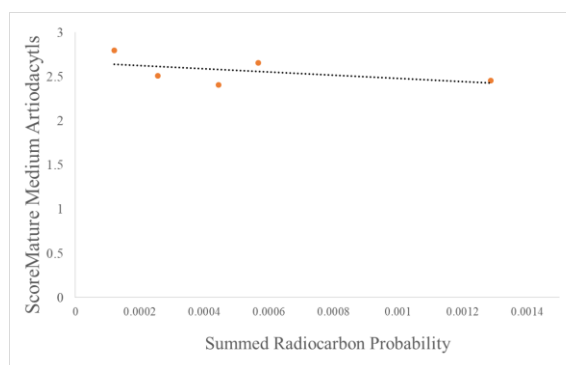
**Figure 0.11.** ScoreMature Bison plotted against modeled average effective moisture.



**Figure 0.14.** ScoreMature Bison plotted against summed radiocarbon probability.



**Figure 0.12.** ScoreMature Medium Artiodactyls plotted against modeled average effective moisture.



**Figure 0.15.** ScoreMature Medium Artiodactyls plotted against summed radiocarbon probability.

### Between Taxon Maturity Differences

The FPE Model predicts that higher-ranked and slower-reproducing prey populations will exhibit the effects of top-down, predation-mediated resource depression before lower-ranked, faster-reproducing populations. Using skeletal fusion data as a proxy for age, I compare the distributions of age groups within different prey taxa to determine when contemporary populations have significantly divergent age profiles. Below, I first compare the age profiles of bison and medium-sized artiodactyl populations using the distributions of fully fused and incompletely fused specimens within each taxa. Next, I compare the age profiles of bighorn sheep and pronghorn populations according to the same method. Table 6.8 lists the fusion distribution for the comparison of bison and medium-size artiodactyls, while Table 6.9 provides the same data for the comparison between bighorn sheep and pronghorn. I test whether these differences in distribution are attributable to chance alone with a series of  $\chi^2$  tests. I did not compare the distribution of fully and incompletely fused deer specimens with those of other medium-sized artiodactyls, as deer are too sparsely represented at Birch Creek to conduct  $\chi^2$  tests.

With higher prey rank and lower reproductive rate, bison populations should always be younger than contemporary populations of medium-sized artiodactyls. This expectation proved true in each of Birch Creek's phases. To test whether this difference in relative age was attributable to chance (my null hypothesis), I ran a  $\chi^2$  test on each phase save Phase I, which was eliminated due to small sample size (Table 6.8). As  $p$ -values for these distributions are all below 0.05, each phase-specific test found statistical differences between the two taxa. This finding is consistent with the predictions of both the prey and FPE models, since bison, as the highest ranked prey on the Snake River

**Table 0-8.**  $\chi^2$  Tests of Bison and Medium-size Artiodactyl Fusion.

Phase	Distribution	Taxon	Fusion >3	Fusion 3	Total
Phase I	Actual	Total	6	16	22
		<i>B. bison</i>	5	2	7
		Medium-sized Artiodactyls	1	14	15
	Expected	<i>B. bison</i>	1.91	5.09	7
		Medium-sized Artiodactyls	4.09	10.91	15
$\chi^2$		Insufficient Sample			
Phase II	Actual	Total	52	187	239
		<i>B. bison</i>	13	16	29
		Medium-sized Artiodactyls	39	171	210
	Expected	<i>B. bison</i>	6.31	22.69	29
		Medium-sized Artiodactyls	45.69	164.31	210
$\chi^2$	7.65	$p = 0.001$			
Phase III	Actual	Total	28	77	105
		<i>B. bison</i>	16	23	39
		Medium-sized Artiodactyls	12	54	66
	Expected	<i>B. bison</i>	10.40	28.60	39
		Medium-sized Artiodactyls	17.60	48.40	66
$\chi^2$	6.54	$p = 0.011$			
Phase IV	Actual	Total	5	39	44
		<i>B. bison</i>	3	7	10
		Medium-sized Artiodactyls	2	32	34
	Expected	<i>B. bison</i>	1.14	8.86	10
		Medium-sized Artiodactyls	3.86	30.14	34
$\chi^2$	9.42	$p = 0.002$			
Phase V	Actual	Total	124	277	402
		<i>B. bison</i>	114	218	332
		Medium-sized Artiodactyls	11	59	70
	Expected	<i>B. bison</i>	102.41	228.77	10
		Medium-sized Artiodactyls	21.59	48.23	34
$\chi^2$	32.20	$p = 1.391\text{E-}08$			

**Table 0-9.**  $\chi^2$  Tests of Antilocapra and Ovis Fusion.

Phase	Distribution	Taxon	Fusion >3	Fusion 3	Total
Phase I	Actual	Total	0	13	13
		<i>A. americana</i>	0	8	8
		<i>O. canadensis</i>	0	5	5
	Expected	<i>A. Americana</i>	0	8	8
		<i>O. canadensis</i>	0	5	5
		Insufficient Sample			
Phase II	Actual	Total	15	105	120
		<i>A. americana</i>	9	59	68
		<i>O. canadensis</i>	6	46	52
	Expected	<i>A. americana</i>	8.50	59.50	68
		<i>O. canadensis</i>	6.50	45.50	52
$\chi^2$	0.08	$p = 0.781$			
Phase III	Actual	Total	6	25	31
		<i>A. americana</i>	5	18	23
		<i>O. canadensis</i>	1	7	8
	Expected	<i>A. americana</i>	4.45	18.55	23
		<i>O. canadensis</i>	1.55	6.45	8
$\chi^2$	0.32	$p = 0.569$			
Phase IV	Actual	Total	5	39	44
		<i>A. americana</i>	2	32	34
		<i>O. canadensis</i>	3	7	10
	Expected	<i>A. americana</i>	3.86	30.14	34
		<i>O. canadensis</i>	1.14	8.86	10
$\chi^2$	4.46	$p = 0.035$			
Phase V	Actual	Total	5	32	37
		<i>A. americana</i>	5	17	22
		<i>O. canadensis</i>	0	15	15
	Expected	<i>A. americana</i>	2.97	19.03	22
		<i>O. canadensis</i>	2.03	12.97	15
$\chi^2$	3.94	$p = 0.047$			

Plain (SRP), should always be taken upon encounter and, consequently, should feel the top-down effects of predation faster than any other prey item, holding growth rate and encounter success equal. The FPE model predicts top-down resource depression to affect slower-reproducing prey before quicker-reproducing prey of the same rank. As such, expectations based upon the FPE model would predict slower reproducing bighorn sheep ( $r = 0.35$  (Cole 1954; Henneman 1983)) to have younger populations than do contemporary populations of quicker-reproducing pronghorn ( $r = 0.45$  (Singer and Norland 1994), or  $r = 0.48$  (Cole 1954; Henneman 1983)). Conversely, the prey model does not account for differences in prey reproductive rates. As such, predictions based upon prey model assumptions do not extend into differences in the fusion rates of similarly ranked taxa.

The Birch Creek assemblage supports prey model expectations (Table 6.8). Contrary to FPE model expectations, Phases II, III, and V contain pronghorn samples with higher proportions of incompletely fused specimens than the sheep samples. Both species are solely represented by fully fused specimens in Phase I. Phase IV, in which bighorn sheep are younger than pronghorn, is the sole phase consistent with FPE expectations.  $\chi^2$  values for both Phases IV ( $\chi^2 = 4.46$ ,  $P = 0.034$ ) and V ( $\chi^2 = 3.94$ ,  $P = 0.047$ )  $\chi^2$  both suggest statistical differences in the fusion rates of the two taxa examined here. In Phase IV, bighorn sheep are younger than pronghorn, whereas the opposite is true in Phase V. Because these statistical differences run in opposite directions, this finding suggests that some other variable beyond reproductive rate alone controls this relationship for the medium artiodactyls. In this context, the lack of predictions made by the prey model predictions are preferable to the inaccurate FPE model predictions.

### Summary

Examination of Birch Creek's prey maturity provides little support for either the prey or FPE model. The lack of significant correlation between SPD and ScoreMature is inconsistent with either model's assumptions about the relationship between hunting pressure and prey age. However, the small sample sizes used throughout this analysis may mask real correlations. For instance, there are negative, but not significant, relationships between medium-sized artiodactyl maturity and all artiodactyl maturity and SPD, which does agree with the prey and FPE model predictions. Contrarily, Bison maturity has a negative, but not significant relationship with SPD, which is inconsistent with model predictions.

Similarly, the lack of any significant correlation between prey age and average annual effective moisture fails to support the predictions of either model. Again, the small sample size used in this analysis may mask the true relationships between my variables. However, the relationships between effective moisture and maturity largely contradict my predictions. Both bison maturity and all artiodactyl maturity have negative relationships with average effective moisture. Only medium artiodactyl maturity trends downward in phases characterized by reduced effective moisture. Unfortunately, without any significant correlations, I cannot offer compelling evidence for or against the predictions of either the FPE or the prey model.

Comparisons of age profiles between taxa, rather than between phases, yielded more interesting results. Consistent with the expectations of both the FPE and prey models, bison are significantly younger in every phase with a sample size large enough to reliably conduct  $\chi^2$  analysis. Consistent with the prey model, but contrary to the FPE



model, I could not find evidence that top-down resource depression affects slower-reproducing prey more readily than quicker-reproducing prey within the same general rank. Ultimately, the more circumscribed prey model predictions proved preferable to inaccurate FPE model predictions.

## **Prey Abundance**

The FPE and prey models both predict that hunting pressure and prey carrying capacity influence NAR (Bayham 1979; Charnov 1976; Charnov and Orians 1973; Emlen 1966; MacArthur and Pianka 1966; Schoener 1971; Stephens and Krebs 1986). As changes to diet breadth and composition influence NAR, in this section I monitor the correlation between the bison and artiodactyl indices, as defined in Chapter 3 and proxy measures for environmental conditions. I use modeled effective moisture as a proxy for carrying capacity, while I use average SPD as a proxy for hunting pressure. Figures 6.16 through 6.21 display the relationships between the prey abundance indices and my environmental proxies. Finally, I present the prey abundance data in tabular form in Tables 6.10 through 6.15.

### **Average Effective Moisture**

My analyses failed to find significant correlations between modeled effective moisture and either of my abundance indices. Birch Creek's Bison Index correlates negatively but not significantly with effective moisture ( $r_s = -0.5$ ,  $p = 0.39$ ). Furthermore, Spearman's rho indicates an even weaker relationship between the

Artiodactyl Index and effective moisture ( $r_s = -0.3$ ,  $p = 0.62$ ). In fact, not only did my analyses fail to find the predicted relationships, the direction of each ran backwards to my expectations, which predicted an increase in high-ranked prey during moister periods characterized by both higher forage quality and availability.

**Table 0-10.** Phase I Faunal Abundance.

Taxon	NISP				MNI			
	10CL3	10CL10	Total	% of Phase	10CL3	10CL10	Total	% of Phase
Centrocerus		1	1	0.73%		1	1	7.14%
Passeriformes		1	1	0.73%		1	1	7.14%
Unidentified Birds	10		10	7.30%	2		2	14.29%
Bison	9	10	19	13.87%	1	1	2	14.29%
Ovis	28	1	29	21.17%	3	1	4	28.57%
Antilocapra	13		13	9.49%	1		1	7.14%
Unidentified Medium Bovids		12	12	8.76%				0.00%
Odocoileus	3		3	2.19%	1		1	7.14%
Unidentified Medium Artiodactyls	6	1	7	5.11%				0.00%
Undientified Medium Mammals	2		2	1.46%				0.00%
Small Mammals	21		21	15.33%				0.00%
Unidentified Artiodactyls	1		1	0.73%				0.00%
Snakes	10		10	7.30%	2		2	14.29%
Unidentified Small	8		8	5.84%				0.00%
Total	111	26	137	100.00%	10	4	14	100.00%

**Table 0-11.** Phase II Faunal Abundance.

Taxon	NISP				MNI			
	10CL3	10CL10	Total	% of Phase	10CL3	10CL10	Total	% of Phase
Centrocercus	21		21	2.19%	3		3	7.69%
Dendragapus	3		3	0.31%	1		1	2.56%
Unidentified Phasianidae	4		4	0.42%				0.00%
Unidentified Passeriformes	1		1	0.10%	1		1	2.56%
Unidentified Birds	83		83	8.65%				0.00%
Bison	36	64	100	10.43%	1	3	4	10.26%
Cervus		1	1	0.10%		1	1	2.56%
Large Unidentified Artiodactyls		1	1	0.10%				0.00%
Antilocapra	165	9	174	18.14%	7	1	8	20.51%
Ovis	173	15	188	19.60%	6	2	8	20.51%
Unidentified Bovidae	95	3	98	10.22%				0.00%
Odocoileus	10	5	15	1.56%	2	1	3	7.69%
Unidentified Medium Artiodactyls	124	7	131	13.66%				0.00%
Canis	32	1	33	3.44%	3	1	4	10.26%
Medium Unidentified Canids	1		1	0.10%				0.00%
Medium Unidentified Carnivores	2		2	0.21%				0.00%
Medium Unidentified Mammals	12		12	1.25%				0.00%
Small Unidentified Canids	1		1	0.10%	1		1	2.56%
Small Unidentified Carnivores	4		4	0.42%	1		1	2.56%
Lepus	7		7	0.73%	2		2	5.13%
Sylvilagus	2		2	0.21%	1		1	2.56%
Rodents	3		3	0.31%	1		1	2.56%
Small Unidentified Mammals	33		33	3.44%				0.00%
Unidentified Artiodactyls	10	1	11	1.15%				0.00%
Unidentified Mammals	8	3	11	1.15%				0.00%
Small Unidentified Specimens	16		16	1.67%				0.00%
Unidentified Specimens	3		3	0.31%				0.00%
Total	849	110	959	100.00%	30	9	39	100.00%

**Table 0-12.** Phase III Faunal Abundance.

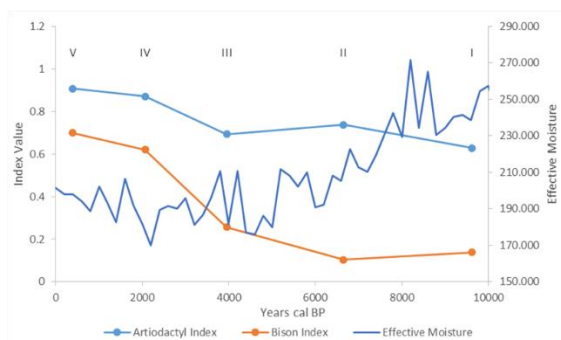
Taxon	NISP				MNI			
	10CL3	10CL10	Total	% of Phase	10CL3	10CL10	Total	% of Phase
Dendragapus	2		2	0.52%	2		2	8.00%
Unidentified Birds	4	1	5	1.31%				
Bison	80	18	98	25.65%	2	3	5	20.00%
Ovis	32	2	34	8.90%	3	1	4	16.00%
Antilocapra	65	1	66	17.28%	4	1	5	20.00%
Unidentified Medium Bovids	50		50	13.09%				
Odocoileus	1		1	0.26%	1		1	4.00%
Unidentified Medium Artiodactyls	16		16	4.19%				
Canis	44		44	11.52%	2		2	8.00%
Lynx	1		1	0.26%	1		1	4.00%
Unidentified Medium Felids	2		2	0.52%				
Unidentified Medium Carnivores	3		3	0.79%				
Unidentified Medium Mammals	21		21	5.50%				
Lepus	2		2	0.52%	1		1	4.00%
Sylvilagus	12		12	3.14%	3		3	12.00%
Rodents	1		1	0.26%	1		1	4.00%
Small Unidentified Mammals	18		18	4.71%				
Unidentified Mammals	3		3	0.79%				
Small Unidentified Specimens	3		3	0.79%				
Total	360	22	382	100.00%	20	5	25	100.00%

**Table 0-13.** Phase IV Faunal Abundance.

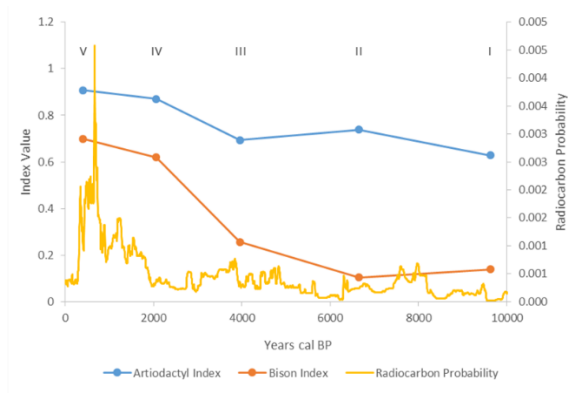
Taxon	NISP				MNI			
	10CL3	10CL10	Total	% of Phase	10CL3	10CL10	Total	% of Phase
Centrocercus	1		1	0.10%	1		1	2.08%
Dendragapus	1		1	0.10%	1		1	2.08%
Unidentified Phasianidae	1		1	0.10%				0.00%
Unidentified Birds	8	1	9	0.86%				0.00%
Bison	500	147	647	62.03%	11	8	19	39.58%
Large Unidentified Artiodactyls	1	2	3	0.29%				0.00%
Large Unidentified Mammals	1		1	0.10%				0.00%
Ovis	40	23	63	6.04%	3	3	6	12.50%
Antilocapra	61	12	73	7.00%	2	2	4	8.33%
Unidentified Medium Bovidae	34	5	39	3.74%				0.00%
Odocoileus	5	20	25	2.40%	1	2	3	6.25%
Unidentified Medium Artiodactyls	21	30	51	4.89%				0.00%
Canis	38	5	43	4.12%	5	1	6	12.50%
Unidentified Medium Carnivores	5		5	0.48%				0.00%
Unidentified Medium Mammals	8		8	0.77%				0.00%
Vulpes	1		1	0.10%	1		1	2.08%
Small Unidentified Canidae	1	1	2	0.19%				0.00%
Unidentified Small Carnivores	2		2	0.19%				0.00%
Lepus	3		3	0.29%		1	1	2.08%
Sylvilagus	5	1	6	0.58%	1	3	4	8.33%
Unidentified Leporids	2		5	0.48%				0.00%
Peromyscus	1		1	0.10%	1		1	2.08%
Unidentified Rodents	2	1	3	0.29%				0.00%
Small Unidentified Mammals	25		25	2.40%				0.00%
Unidentified Bovids	3		3	0.29%				0.00%
Unidentified Artiodactyls	2		2	0.19%				0.00%
Unidentified Mammals	6		6	0.58%				0.00%
Snakes	4		4	0.38%	1		1	2.08%
Small Unidentified Specimens	7		7	0.67%				0.00%
Unidentified Specimens	2	1	3	0.29%				0.00%
Total	791	249	1043	100.00%	28	20	48	100.00%

**Table 0-14.** Phase V Faunal Abundance.

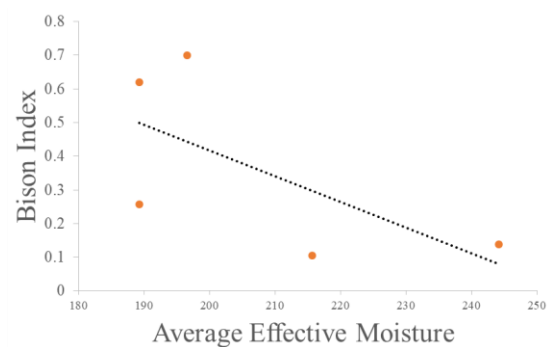
Taxon	NISP				MNI			
	10CL3	10CL10	Total	% of Phase	10CL3	10CL10	Total	% of Phase
Dendragapus		1	1	0.09%		1	1	2.38%
Unidentified Phasianidae	1		1	0.09%	1		1	2.38%
Unidentified Birds	5	4	9	0.81%				0.00%
Bison	123	650	773	69.95%	4	15	19	45.24%
Large Unidentified Bovids	1		1	0.09%				0.00%
Large Unidentified Artiodactyls	3	5	8	0.72%				0.00%
Large Unidentified Mammals		1	1	0.09%				0.00%
Ovis	14	44	58	5.25%	3	2	5	11.90%
Antilocapra	10	38	48	4.34%	1	1	2	4.76%
Unidentified Medium Bovids	5	15	20	1.81%				0.00%
Odocoileus	4	36	40	3.62%	1	4	5	11.90%
Unidentified Medium Artiodactyls	12	38	50	4.52%				0.00%
Canis	36	23	59	5.34%	2	2	4	9.52%
Lynx	1		1	0.09%	1		1	2.38%
Unidentified Medium Carnivores	1		1	0.09%				0.00%
Unidentified Medium Mammals		7	7	0.63%				0.00%
Lepus		2	2	0.18%		1	1	2.38%
Sylvilagus	3	2	5	0.45%	1	1	2	4.76%
Citellus	1	2	3	0.27%		1	1	2.38%
Unidentified Rodents	2		2	0.18%				0.00%
Small Unidentified Mammals	8		8	0.72%				0.00%
Unidentified Artiodactyls		4	4	0.36%				0.00%
Unidentified Small Specimens	1	1	2	0.18%				0.00%
Unidentified Specimens	1		1	0.09%				0.00%
Total	232	873	1105	100.00%	14	28	42	100.00%



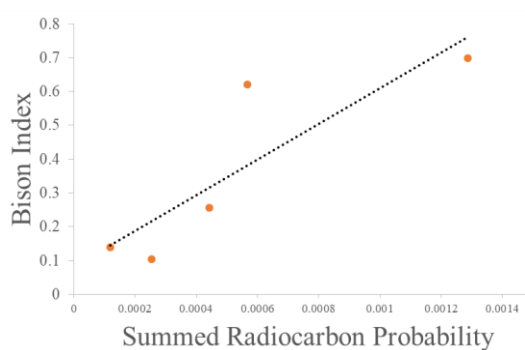
**Figure 0.16.** Abundance indices for bison and all artiodactyls arrayed against modeled effective moisture.



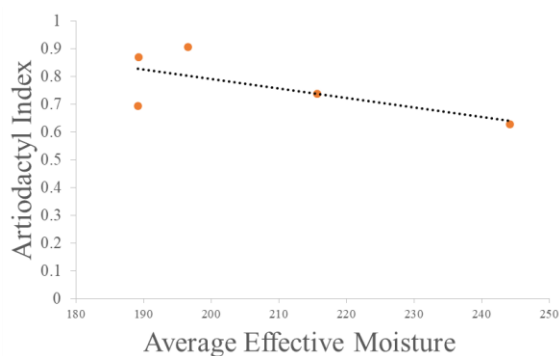
**Figure 0.17.** Abundance indices for bison and all artiodactyls arrayed against Idaho's summed radiocarbon probability distribution.



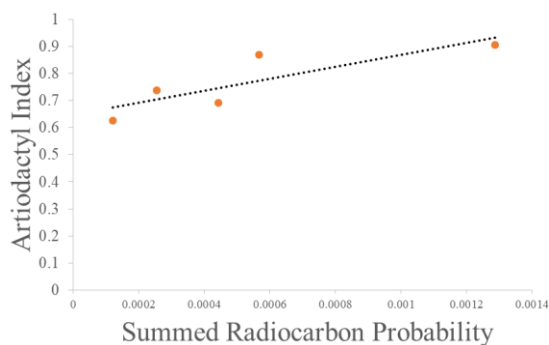
**Figure 0.18.** Bison Index plotted against modeled effective moisture.



**Figure 0.19.** Bison Index plotted against summed radiocarbon probability.



**Figure 0.20.** Artiodactyl Index plotted against modeled effective moisture.



**Figure 0.21.** Artiodactyl Index plotted against summed radiocarbon probability.

**Table 0-15.** Abundance Indices by Phase.

Index	Phase I	Phase II	Phase III	Phase IV	Phase V
Bison	0.14	0.1	0.26	0.62	0.7
Artiodactyl	0.63	0.74	0.69	0.87	0.91

#### Average Summed Radiocarbon Probability

In contrast to the comparisons with effective moisture, my research did find significant relationships between my abundance indices and SPD. In this instance, both the bison index ( $r_s = 0.9$ ,  $p = 0.04$ ) and the more broadly defined artiodactyl index ( $r_s = 0.9$ ,  $p = 0.04$ ) correlate positively and significantly with SPD (Figures 6.19 and 6.21). This means that apparent increases in population density correspond to an increase in the proportion of the Birch Creek diet composed of artiodactyls in particular, and bison specifically. In both cases, these findings contradict the expectations of the prey and FPE models, which predict that denser human populations lead to greater hunting pressure. This in turn should drive down higher-ranked prey populations and result in greater relative abundances of lower-ranked, smaller prey in the related archaeofaunas.

#### Summary

The correlation of prey abundance indices with my environmental variables yielded interesting results. Average annual effective moisture does not correlate significantly with either abundance index. This finding fails to support my prediction that reduced effective moisture should result in less numerous game, obliging hunters to pursue lower-ranked prey with greater frequency. Moreover, both abundance indices correlate significantly and positively with SPD, suggesting that high-ranked prey populations increased along with human populations. This



finding contradicts the expectations of both the prey and FPE models even more strongly; both models make the opposite prediction: denser populations should include less high-ranked prey in their diets. However, the findings in this study come from a single dataset. These findings may be an artifact of foraging strategies that can only be accurately monitored through the study of multiple sites

### **Processing Intensity**

A number of studies have shown that changes in processing intensity can indicate a change in NAR (Binford 1978; Breslawski and Byers 2015; Burger et al. 2005; Smith et al. 2008), which, in this study, the FPE and prey models predict to fluctuate with changes to environmental conditions. I use processing intensity to refer to effort that consumers spend extracting resources from prey items. I monitor the correlation between proxies for processing intensity and environmental conditions. My proxies for processing intensity are NISP/MNE, %Intact, %WetBreak, %Speciated, and %Discarded, all of which I define in Chapter 3. Values for these proxies are presented by phase in Tables 6.16 through 6.20. I graphically display the relationship between my proxies for processing intensity and environmental conditions in Figures 6.22 through 6.48. I also report the correlation coefficients and related p-values in Tables 6.21 and 6.22. In these tables, the *indication* column indicates whether the direction of each relationship is consistent or inconsistent with my predictions. For the tests below, I use the null hypothesis “Y index varies randomly with respect to X variable,” where Y is either the bison or artiodactyl index and X is the relevant environmental variable.

**Table 0-16.** Phase I Taphonomy Data.

Taxon	NISP	NISP Intact	Percent Intact	Wet Bone Breakage	Wet Bone Breakage Percent
Centrocercus	1	0	0.00%	0	0.00%
Passeriformes	1	0	0.00%	1	100.00%
Unidentified Birds	11	3	27.27%	3	27.27%
Bison	19	10	52.63%	0	0.00%
Ovis	29	8	27.59%	13	44.83%
Antilocapra	13	5	38.46%	6	46.15%
Unidentified Medium Bovids	12	2	16.67%	2	16.67%
Odocoileus	3	1	33.33%	0	0.00%
Unidentified Medium Artiodactyls	7	0	0.00%	3	42.86%
Unidentified Medium Mammals	2	0	0.00%	1	50.00%
Small Mammals	21	5	23.81%	0	0.00%
Unidentified Artiodactyls	1	0	0.00%	0	0.00%
Snakes	10	9	90.00%	0	0.00%
Unidentified Small	8	0	0.00%	0	0.00%
Total	137	44	0.32117	29	0.211678832

Processing proxies that correlate significantly with average annual effective moisture contradict the expectations of the FPE and prey models. %WetBreak All Specimens and %WetBreak Medium Artiodactyls correlate significantly and positively with average annual effective moisture and in both cases returned the same correlation values ( $r_s = 0.9$ ,  $p = 0.04$ ). This means that rising effective moisture corresponds to a greater incidence of wet bone breakage for both the set of all specimens and the set of medium artiodactyl remains. This positive correlation contradicts my expectation that Birch Creek's inhabitants need process carcasses less intensively when foraging, and therefore prey is more abundant. Instead, when game should be most abundant, Birch Creek's inhabitants processed carcasses with greater intensity, lowering their NAR in exchange for a greater total caloric yield.

**Table 0-17.** Phase II Taphonomy Data.

Taxon	NISP	NISP Intact	Percent Intact	Wet Bone Breakage	Wet Bone Breakage Percent
Centrocercus	21	1	4.76%	6	28.57%
Dendragapus	3	1	33.33%	0	0.00%
Unidentified Phasianidae	4	2	50.00%	0	0.00%
Unidentified Passeriformes	1	0	0.00%	0	0.00%
Unidentified Birds	83	20	24.10%	19	22.89%
Bison	100	48	48.00%	17	17.00%
Cervus	1	0	0.00%	0	0.00%
Large Unidentified	1	0	0.00%	0	0.00%
Antilocapra	174	73	41.95%	59	33.91%
Ovis	188	67	35.64%	67	35.64%
Unidentified Medium Bovidae	98	16	16.33%	41	41.84%
Odocoileus	15	10	66.67%	2	13.33%
Unidentified Medium Artiodactyls	131	26	19.85%	49	37.40%
Canis	33	6	18.18%	10	30.30%
Unidentified Canids	1	1	100.00%	0	0.00%
Unidentified Carnivores	2	2	100.00%	0	0.00%
Unidentified Medium Mammals	12	3	25.00%	0	0.00%
Unidentified Small Carnids	1	0	0.00%	1	100.00%
Unidentified Small Carnivores	4	4	100.00%	0	0.00%
Lepus	7	1	14.29%	0	0.00%
Sylvilagus	2	1	50.00%	0	0.00%
Rodents	3	0	0.00%	0	0.00%
Small Unidentified Mammals	33	5	15.15%	5	15.15%
Unidentified Artiodactyls	11	8	72.73%	0	0.00%
Unidentified Mammls	11	5	45.45%	4	36.36%
Small Unidentified Specimens	16	3	18.75%	5	31.25%
Unidentified Specimens	3	0	0.00%	0	0.00%
Total	959	303	31.60%	285	29.72%

**Table 0-18.** Phase III Taphonomy Data.

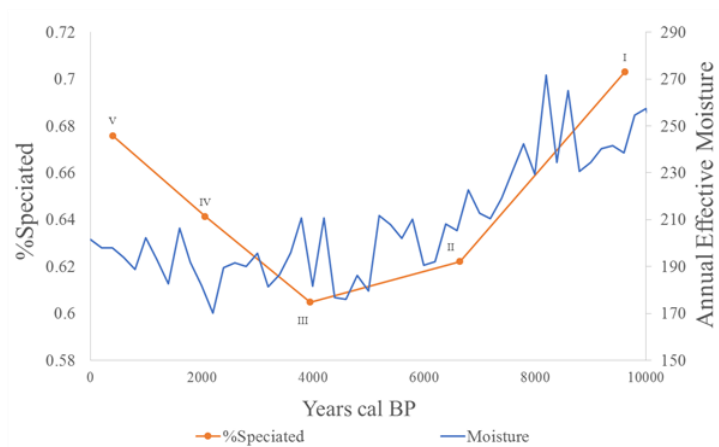
Taxon	NISP	NISP Intact	Percent Intact	Wet Bone Breakage	Wet Breakage Percent
Dendragapus	2	1	50.00%	0	0.00%
Unidentified Birds	5	1	20.00%	2	40.00%
Bison	98	43	43.88%	11	11.22%
Ovis	34	14	41.18%	7	20.59%
Antilocapra	66	29	43.94%	17	25.76%
Unidentified Medium Bovids	50	5	10.00%	23	46.00%
Odocoileus	1	1	100.00%	0	0.00%
Unidentified Medium Artiodactyls	16	7	43.75%	4	25.00%
Canis	44	10	22.73%	0	0.00%
Lynx	1	0	0.00%	1	100.00%
Unidentified Medium Felids	2	0	0.00%	1	50.00%
Unidentified Medium Carnivores	3	1	33.33%	0	0.00%
Unidentified Medium Mammals	21	1	4.76%	1	4.76%
Lepus	2	0	0.00%	2	100.00%
Sylvilagus	12	3	25.00%	0	0.00%
Rodents	1	0	0.00%	0	0.00%
Small Unidentified Mammals	18	4	22.22%	4	22.22%
Unidentified Mammals	3	0	0.00%	0	0.00%
Small Unidentified Specimens	3	0	0.00%	0	0.00%
Total	382	120	31.41%	73	19.11%

**Table 0-19.** Phase IV Taphonomy Data.

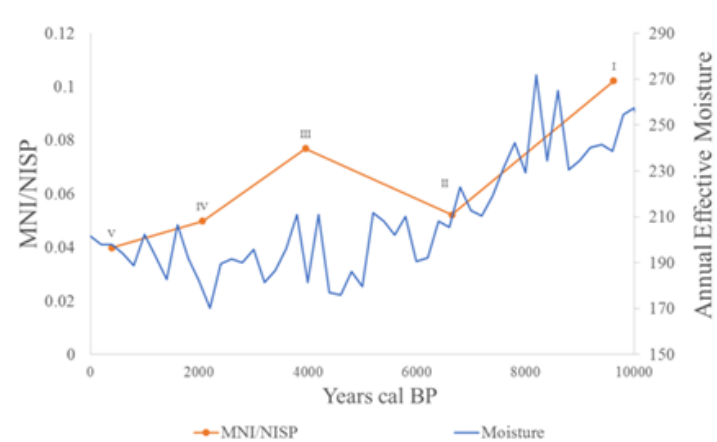
Taxon	NISP	NISP Intact	Percent Intact	Wet Bone Breakage	Wet Bone Breakage Percent
Centrocercus	1	1	100.00%	0	0.00%
Dendragapus	1	1	100.00%	0	0.00%
Unidentified Phasianidae	1	0	0.00%	0	0.00%
Unidentified Birds	9	4	44.44%	0	0.00%
Bison	647	303	46.83%	95	14.68%
Large Unidentified Artiodactyls	3	1	33.33%	1	33.33%
Large Unidentified Mammals	1	1	100.00%	0	0.00%
Ovis	63	26	41.27%	19	30.16%
Antilocapra	73	24	32.88%	30	41.10%
Unidentified Medium Bovidae	39	8	20.51%	15	38.46%
Odocoileus	25	10	40.00%	10	40.00%
Unidentified Medium Artiodactyls	51	26	50.98%	7	13.73%
Canis	43	14	32.56%	7	16.28%
Unidentified Medium Carnivores	5	1	20.00%	1	20.00%
Unidentified Medium Mammals	8	4	50.00%	0	0.00%
Vulpes	1	1	100.00%	0	0.00%
Small Unidentified Canidae	2	2	100.00%	0	0.00%
Unidentified Small Carnivores	2	2	100.00%	0	0.00%
Lepus	3	0	0.00%	0	0.00%
Sylvilagus	6	1	16.67%	0	0.00%
Unidentified Leporids	5	1	20.00%	0	0.00%
Peromyscus	1	0	0.00%	0	0.00%
Unidentified Rodents	3	0	0.00%	0	0.00%
Small Unidentified Mammals	25	5	20.00%	0	0.00%
Unidentified Bovids	3	0	0.00%	0	0.00%
Unidentified Artiodactyls	2	0	0.00%	0	0.00%
Unidentified Mammals	6	0	0.00%	1	16.67%
Snakes	4	3	75.00%	0	0.00%
Small Unidentified Specimens	7	0	0.00%	1	14.29%
Unidentified Specimens	3	1	33.33%	0	0.00%
Total	1043	440	42.19%	187	17.93%

**Table 0-20.** Phase V Taphonomy Data.

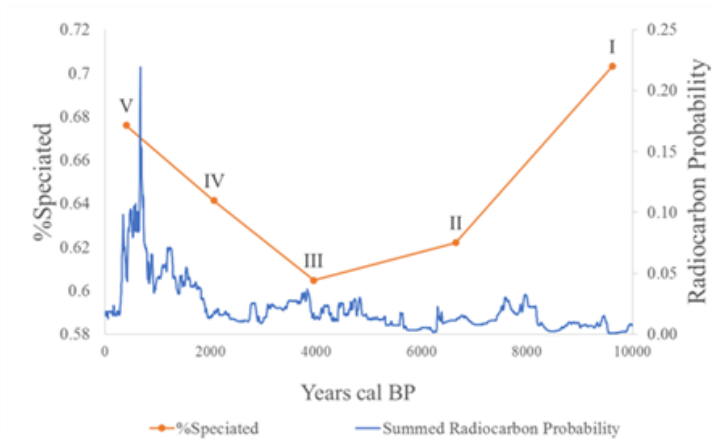
Taxon	NISP	NISP Intact	Percent Intact	NISP Wet Bone Breakage	Wet Bone Breakage Percent
Dendragapus	1	1	100.00%	0	0
Unidentified Phasianidae	1	0	0.00%	0	0.00%
Unidentified Birds	9	3	33.33%	1	11.11%
Bison	773	337	43.60%	125	16.17%
Large Unidentified Bovids	1	0	0.00%	0	0.00%
Large Unidentified Artiodactyls	8	4	50.00%	0	0.00%
Large Unidentified Mammals	1	0	0.00%	0	0.00%
Ovis	58	11	18.97%	23	39.66%
Antilocapra	48	27	56.25%	19	39.58%
Unidentified Medium Bovids	20	8	40.00%	8	40.00%
Odocoileus	40	14	35.00%	14	35.00%
Unidentified Medium Artiodactyls	50	22	44.00%	14	28.00%
Canis	59	27	45.76%	8	13.56%
Lynx	1	0	0.00%	0	0.00%
Unidentified Medium Carnivores	1	0	0.00%	0	0.00%
Unidentified Medium Mammals	7	5	71.43%	2	28.57%
Lepus	2	0	0.00%	0	0.00%
Sylvilagus	5	0	0.00%	0	0.00%
Citellus	3	2	66.67%	0	0.00%
Unidentified Rodents	2	0	0.00%	0	0.00%
Small Unidentified Mammals	8	1	12.50%	0	0.00%
Unidentified Artiodactyls	4	3	75.00%	0	0.00%
Unidentified Small Specimens	2	1	50.00%	0	0.00%
Unidentified Specimens	1	0	0.00%	0	0.00%
Total	1105	466	42.17%	214	19.37%



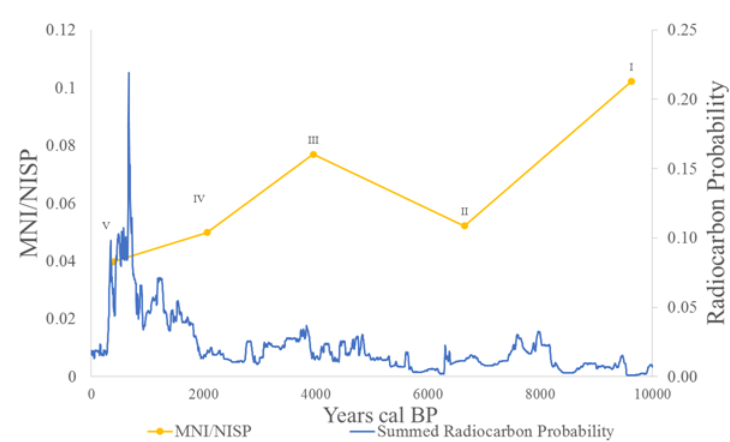
**Figure 0.22.** %Speciated arrayed against modeled effective moisture.



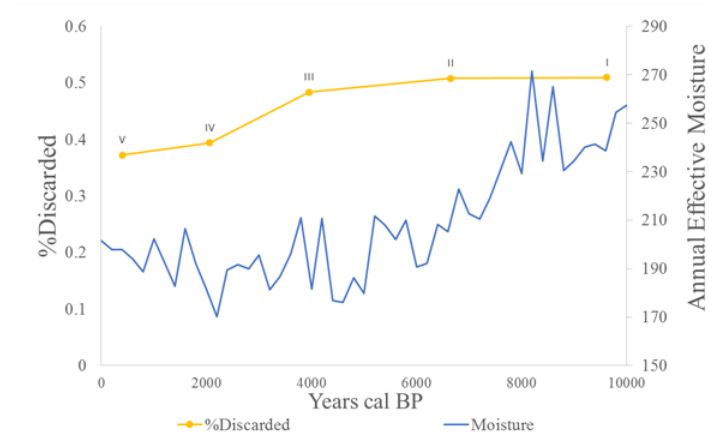
**Figure 0.24.** MNI/NISP arrayed against modeled effective moisture.



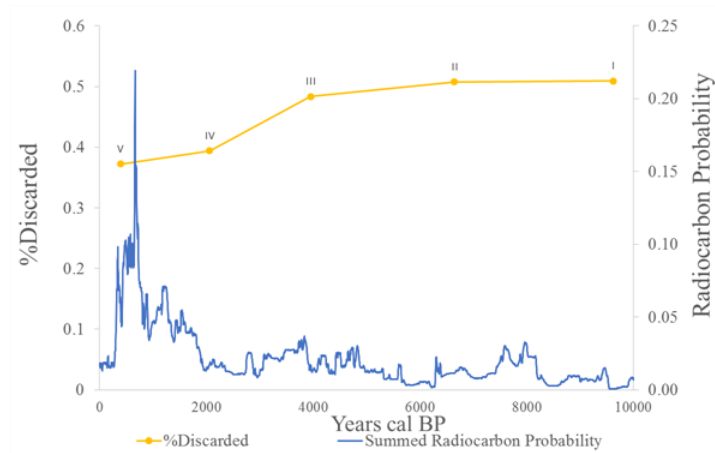
**Figure 0.23.** %Speciated arrayed against radiocarbon probability.



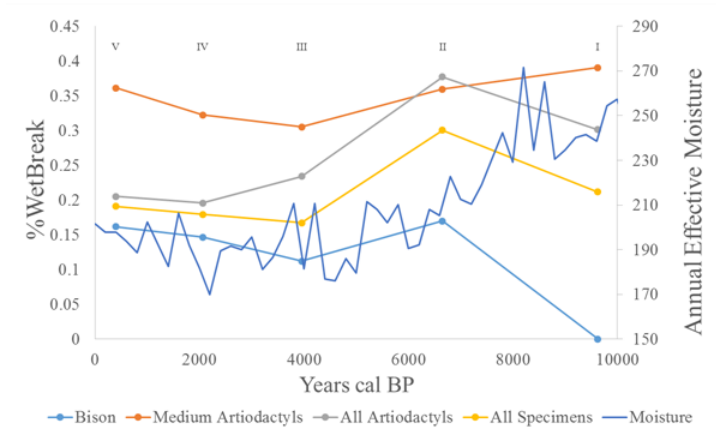
**Figure 0.25.** MNI/NISP arrayed against radiocarbon probability.



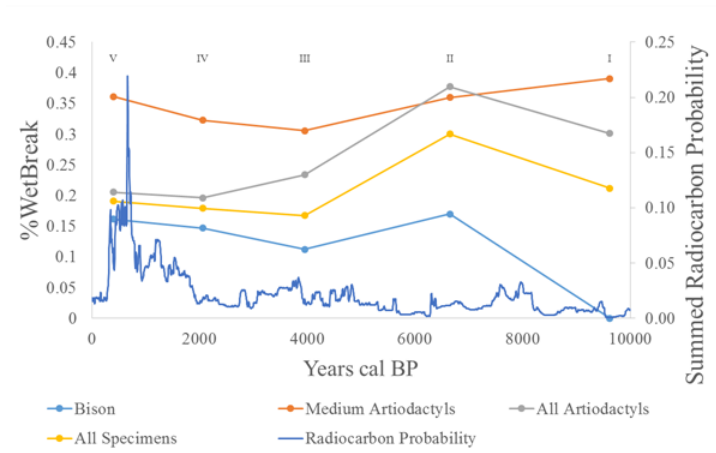
**Figure 0.26.** %Discarded arrayed against modeled effective moisture.



**Figure 0.27.** %Discarded arrayed against radiocarbon probability.

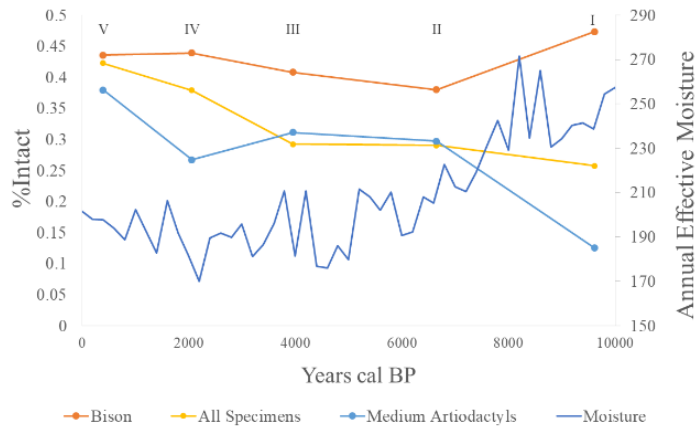


**Figure 0.28.** %WetBreak arrayed against modeled effective moisture.

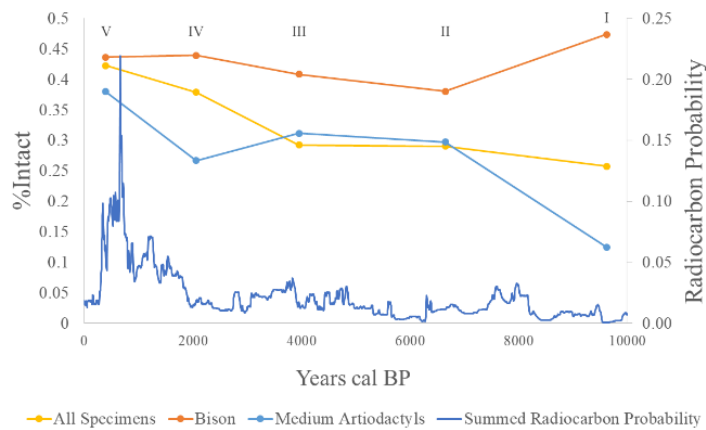


**Figure 0.29.** %WetBreak arrayed against radiocarbon probability.

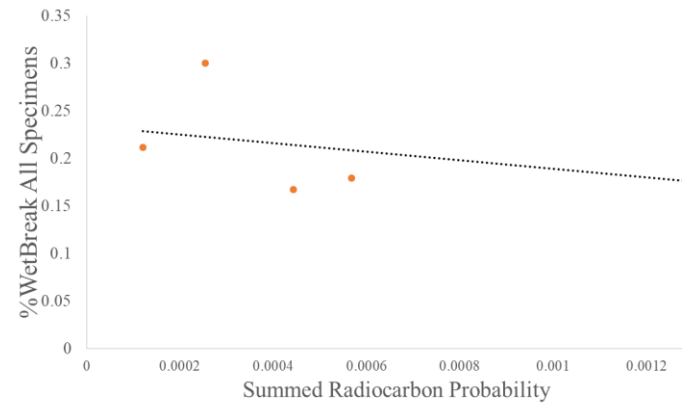




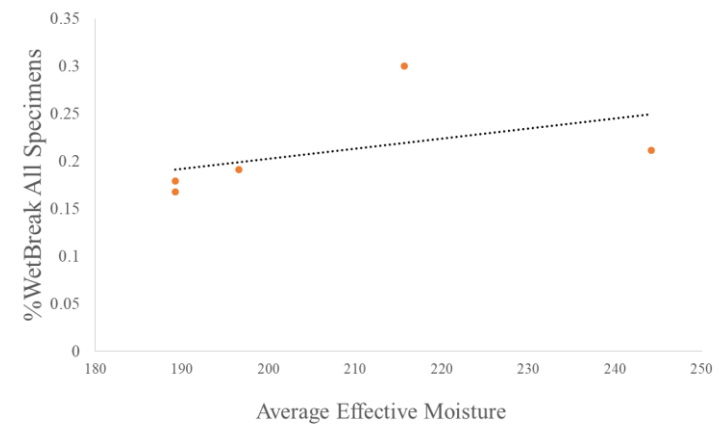
**Figure 0.30.** %Intact arrayed against modeled effective moisture.



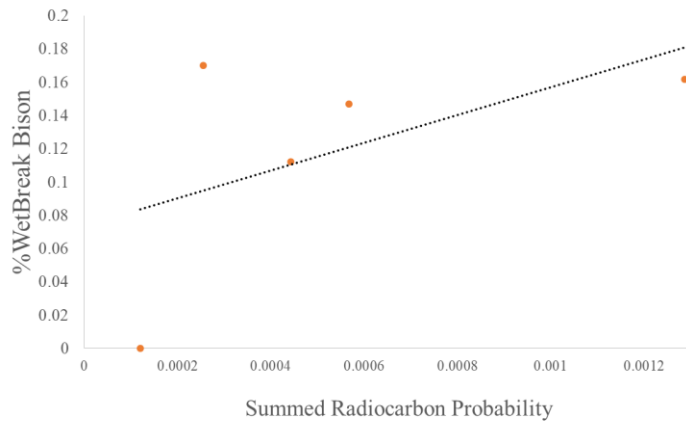
**Figure 0.31.** %Intact arrayed against radiocarbon probability.



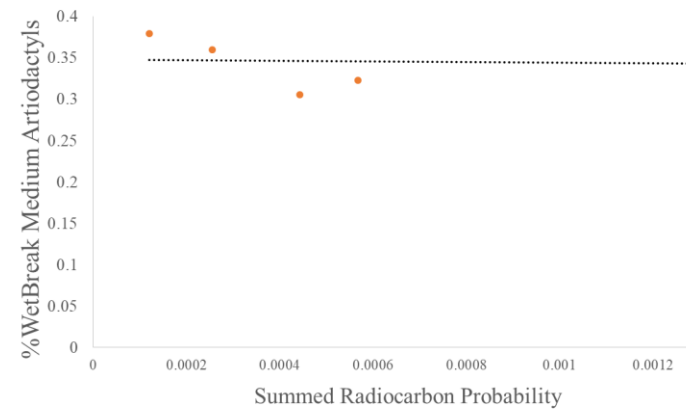
**Figure 0.32.** %WetBreak All Specimens arrayed against summed radiocarbon probability.



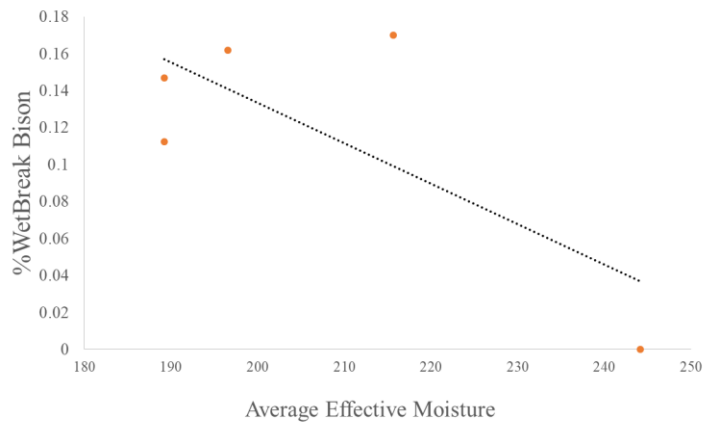
**Figure 0.33.** %WetBreak All Specimens and modeled effective moisture.



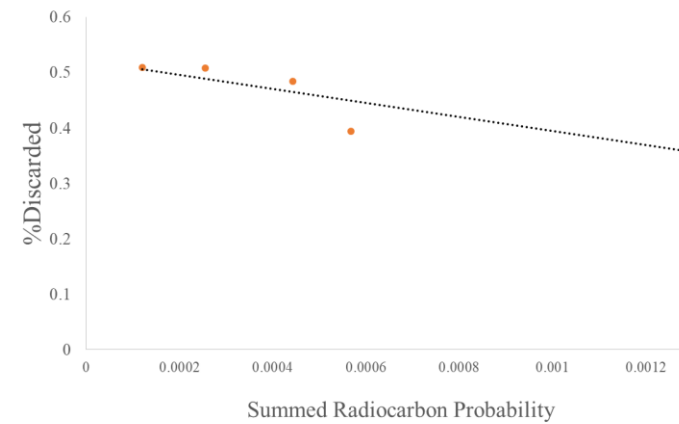
**Figure 0.34.** %WetBreak Bison plotted against summed radiocarbon probability.



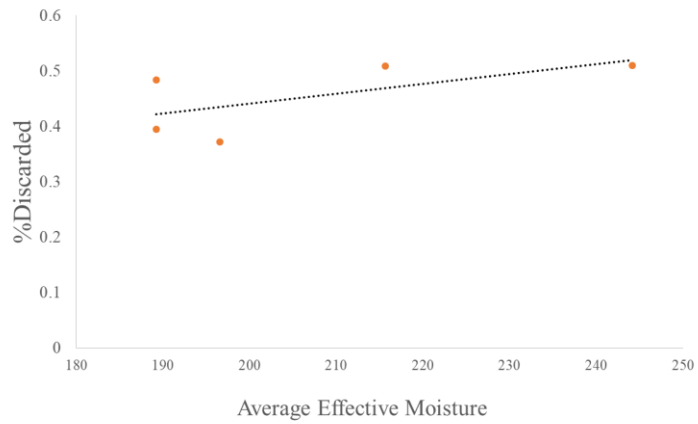
**Figure 0.36.** %WetBreak Medium Artiodactyls plotted against summed radiocarbon probability.



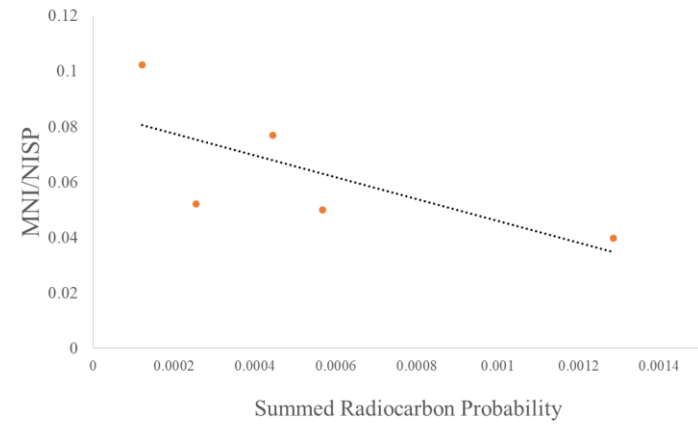
**Figure 0.35.** %WetBreak Bison plotted against modeled effective moisture.



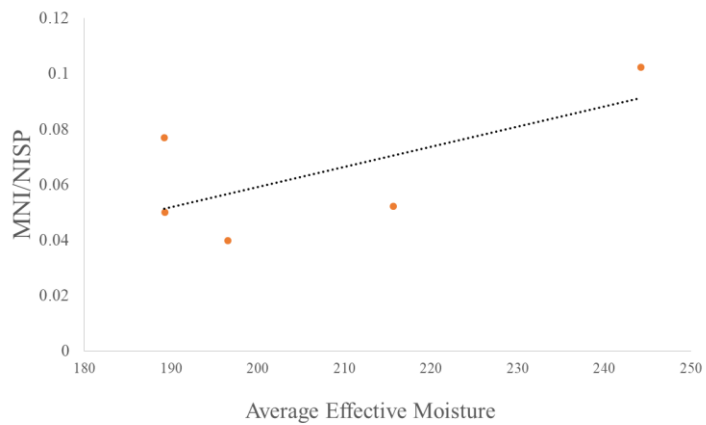
**Figure 0.37.** %Discarded plotted against summed radiocarbon probability.



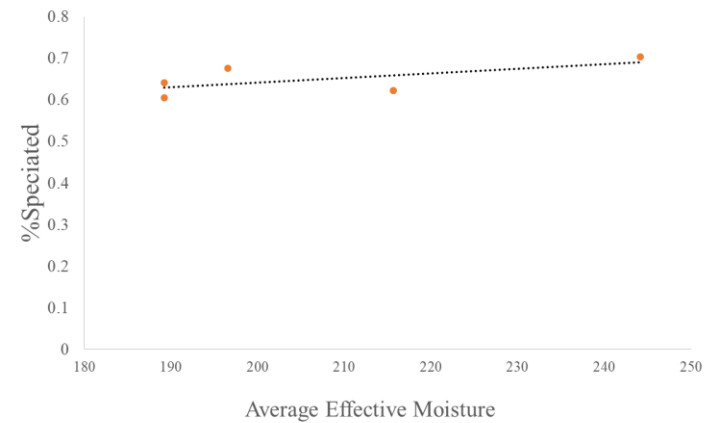
**Figure 0.38.** %Discarded plotted against modeled effective moisture.



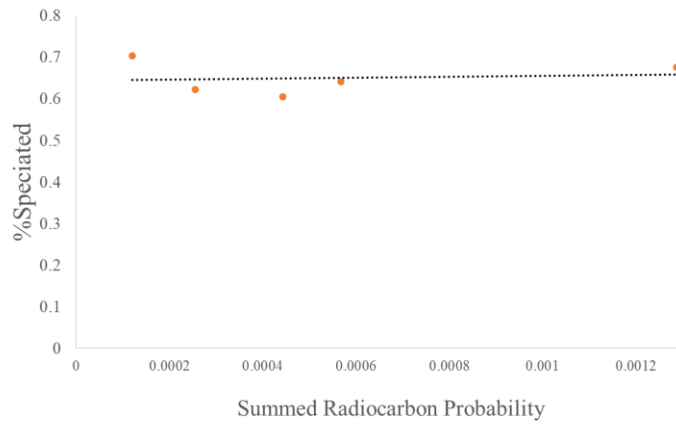
**Figure 0.40.** MNI/NISP and summed radiocarbon probability.



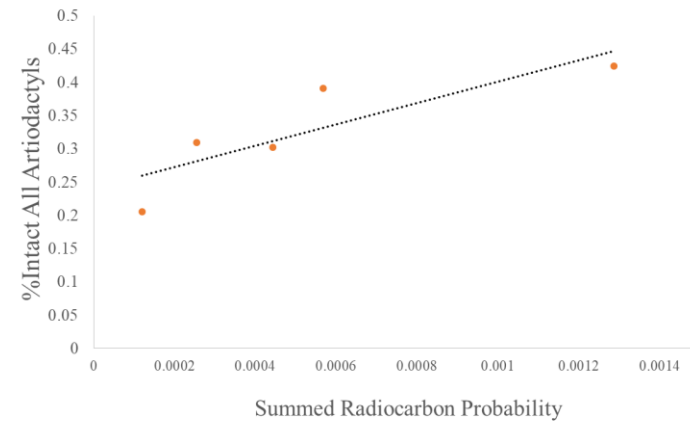
**Figure 0.39.** MNI/NISP plotted against modeled effective moisture.



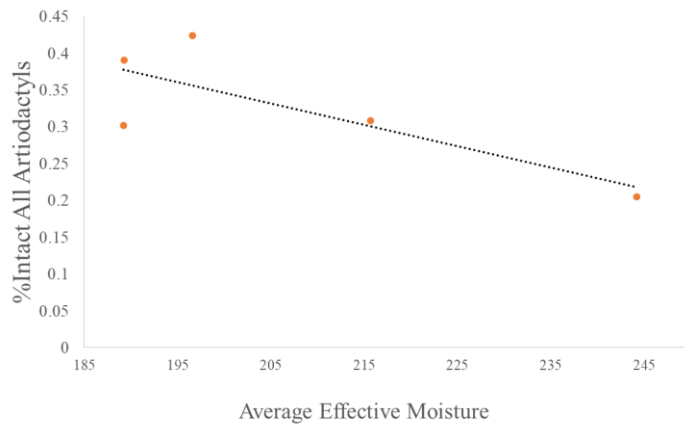
**Figure 0.41.** %Speciated and modeled effective moisture.



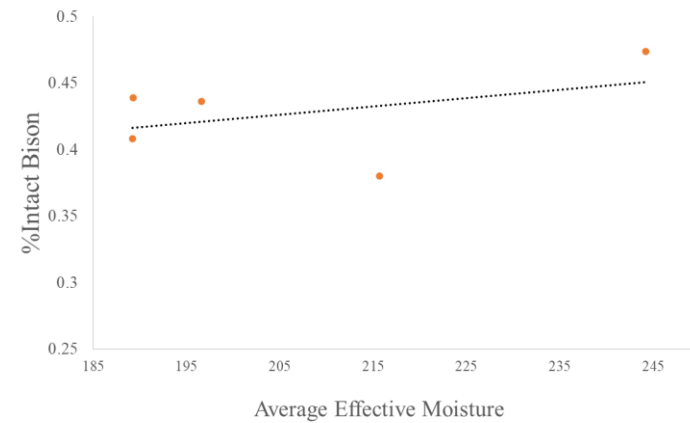
**Figure 0.42.** %Speciated and summed radiocarbon probability.



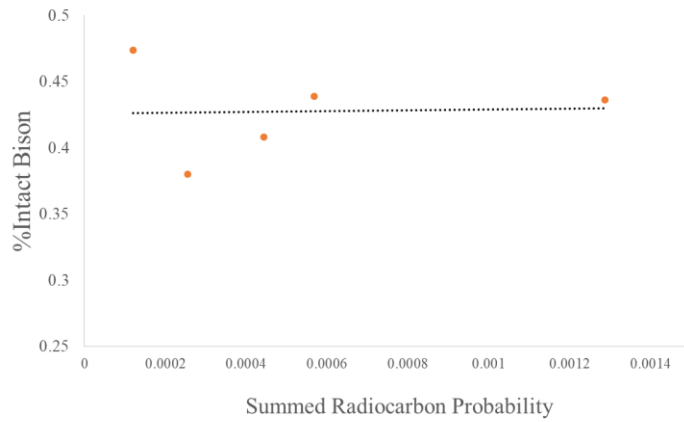
**Figure 0.44.** %Intact All Artiodactyls and summed radiocarbon probability.



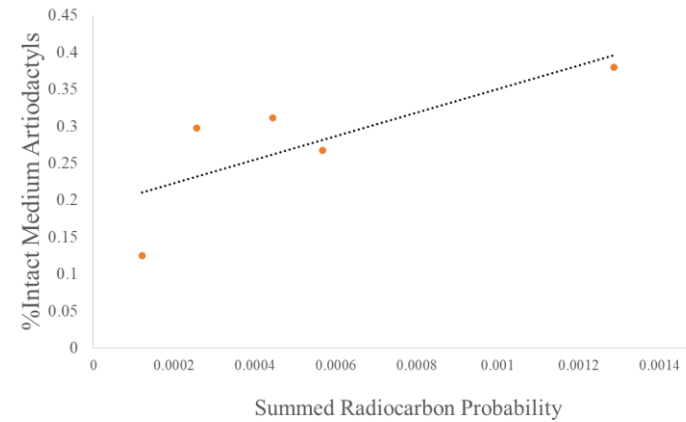
**Figure 0.43.** Intact All Artiodactyls and modeled effective moisture.



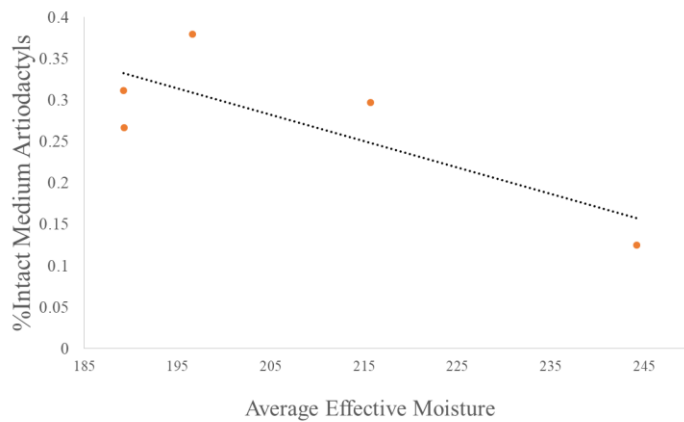
**Figure 0.45.** %Intact Bison and modeled effective moisture



**Figure 0.46.** %Intact Bison and summed radiocarbon probability.



**Figure 0.48.** %Intact Medium Artiodactyls and summed radiocarbon probability.



**Figure 0.47.** %Intact Medium Artiodactyls and modeled effective moisture.

In addition to the evidence provided by the significant relationships, %Intact Bison ( $r_s = -0.7, p = 0.19$ ), %Intact Medium Artiodactyls ( $r_s = -0.5, p = 0.39$ ), and %Intact All Artiodactyls ( $r_s = -0.3, p = 0.62$ ) are all negatively associated with effective moisture, indicating increased fragmentation of assemblages from phases characterized by low moisture conditions. Similarly, %Discarded ( $r_s = 0.6, p = 0.19$ ) has a positive relationship with effective moisture. In contrast, only two processing proxies have relationships consistent with either foraging model. %Speciated ( $r_s = 0.7, p = 0.19$ ) and MNI/NISP ( $r_s = -0.3, p = 0.62$ ) both indicate reduced processing intensity in phases with more effective moisture, but these proxies are both weaker measures of processing intensity than %WetBreak, as they rely upon unconfirmed assumptions about Swanson's curation practices (see Chapter 3). Interestingly, %WetBreak Bison is entirely uncorrelated with effective moisture ( $r_s = 0.0, p = 1$ ). While small sample size may be masking significant correlations between some processing intensity proxies and effective moisture, the preponderance of evidence from the Birch Creek archaeofauna indicates a positive relationship between processing intensity and average annual effective moisture.

My processing proxies provide mixed indications for the relationship between processing intensity and human population density. %Intact Bison co-varies significantly and positively with SPD ( $r_s = 0.9, p = 0.04$ ). This indicates less intensive processing of bison elements by Birch Creek inhabitants when the SPD data suggest that Idaho had denser populations. Furthermore, %Discarded co-varies negatively and significantly with SPD ( $r_s = -1, p = 0$ ). This means that fewer specimens were discarded from the phases in which Idaho had a denser apparent population. Since, as described in Chapter 3, I consider discarded specimens likely to represent small and unidentifiable bone fragments

**Table 0-21.** Spearman's Rho for Processing Intensity Proxies and Average Annual Effective Moisture.

Indication	Processing Proxy	$r_s$	$p$
Consistent	% Speciated	0.7	0.19
	MNI/NISP	-0.3	0.62
	% WetBreak Bison	0	1
Inconsistent	% WetBreak Medium Artiodactyls	0.9	0.04
	% WetBreak All Specimens	0.9	0.04
	% Intact Bison	-0.7	0.19
	% Discarded	0.6	0.28
	% Intact Medium Artiodactyls	-0.5	0.39
	% Intact All Artiodactyls	-0.3	0.62

**Table 0-22:** Spearman's Rho for Processing Intensity Proxies and Summed Radiocarbon Probability.

Indication	Processing Proxy	$r_s$	$p$
Inconsistent	% Discarded	-1	0
	% Intact Bison	0.9	0.04
	% Speciated	0.7	0.19
	% Intact Medium Artiodactyl	0.7	0.19
	% WetBreak All Specimens	-0.5	0.39
	% WetBreak Medium Artiodactyls	-0.3	0.62
Consistent	MNI/NISP	-0.9	0.04
	Bison % WetBreak	0.4	0.50
	% Intact All Artiodactyls	-0.1	0.87

resulting from more intensive processing behaviors, a reduction in %Discarded as SPD increases indicates reduced processing intensity as human population increases. Both of these relationships, however, run contrary to my expectations and instead indicate a reduction in processing intensity during periods of higher population density.

Conversely, my analysis found a significant, negative correlation between the MNI/NISP ratio and SPD ( $r_s = -0.9$ ,  $p = 0.04$ ). As discussed in Chapter 3, I assume an inverse relationship between MNI/NISP and processing intensity. This means that more identified specimens represented proportionally fewer individuals in phases with denser

human populations. This finding is consistent with the predictions of both the FPE and prey models, and conflicts with the other two significant correlations seen between processing intensity and SPD, both of which indicate a decrease in processing intensity as SPD increases. However, as %Discarded co-varies positively with SPD, the contrary correlation of MNI/NISP and SPD may result from the discard of specimens, rather than from the processing behavior of Birch Creek inhabitants.

### Summary

Correlation of processing intensity proxies with environmental conditions contradicted the expectations of the FPE and prey models. While the negative correlation of MNI/NISP, provides some indication of increased processing intensity during high population phases, %Discarded and %Intact Bison both indicate reduced processing with increased population. Furthermore, more specimens show signs of wet bone breakage in phases with higher average effective moisture. Thus, both environmental variables correlate with greater processing intensity, in contradiction to the FPE and prey models.

### Summary

In Chapter 6, I used the FPE and prey models to create and test predictions about relationships between attributes of the Birch Creek archaeofauna, climate, and human demography. These predictions provided me with testable expectations about the manner in which my measures for NAR would correlate with human demography and environmental productivity. Within this context, I predicted that diets would expand to



include lower ranked food items as human population rises and as landscape productivity declines. This expansion should either occur through the addition of lower-ranked prey species, or through more thorough consumption of those prey already included in the diet.

My analyses of the relationships between average annual effective moisture and the Birch Creek faunal assemblage largely fail to support my predictions, and in the cases of %WetBreak All Specimens and %WetBreak Medium Artiodactyls, contradict them entirely. No measure of prey maturity or prey abundance correlates significantly with annual average effective moisture. Moreover, the two measures of processing intensity that significantly correlate with average annual effective moisture, %WetBreak All Specimens and %WetBreak Medium Artiodactyls, do so positively, which indicates a positive relationship between effective moisture and processing intensity. These relationships are, of course, entirely contrary to my predictions.

In contrast with the results of the climate-based analyses, SPD correlates significantly with five of my faunal variables, %Intact Bison, %Discarded, MNI/NISP, Artiodactyl Abundance Index, and Bison Abundance Index. I did not detect any significant relationship between SPD the ScoreMature of any taxon. Both the Artiodactyl Abundance Index and the Bison Abundance Index correlate positively with summed radiocarbon probability, indicating increased consumption of higher-ranked prey during phases with dense human populations. These correlations run counter to the expectations of either model for foraging behavior. The processing proxies %Intact Bison and %Discarded both correlate significantly with SPD, ( $r_s = 0.9$ ,  $p = 0.04$ ) and ( $r_s = -1$ ,  $p = 0.00$ ) respectively, indicating that prey were processed less intensively in phases

characterized by more people on the landscape, results that support the predictions of both the FPE and the prey model. However, MNI/NISP correlates negatively with SPD, indicating that prey were more intensively processed when more people were on the landscape. Consideration of these three variables with SPD provides a reasonable weight of evidence that contradicts the premises of both the FPE and prey models. Analyses of relationships between faunal variables and SPD produced results that generally contradict my expectations.

The results of my statistical analyses largely failed to support my initial expectations. Instead, they provided a great deal of contradictory and ambiguous evidence. In the following chapter, Discussion and Conclusion, I attempt to reconcile these contradictions and ambiguities. I address the shortcomings of the Birch Creek archaeofauna for testing and comparing the FPE and prey models. I also suggest new avenues of inquiry that may better answer the questions raised elsewhere in this paper.

## DISCUSSION AND CONCLUSION

In the preceding chapters, I proposed an optimal foraging model grounded by prey population dynamics. I based my research on a specific version of the prey model, in particular, the FPE model (Winterhalder and Lu 1997), which incorporates the reproductive attributes of prey to predict the outcomes of foraging behavior. My test data come from the Birch Creek archaeofaunal assemblage, which I initially thought suitable for studying the problem of integrating the prey model with the population dynamics of prey species.

Population dynamics are governed by the top-down controls of predators, the bottom-up controls of forage availability, and the rates of intrinsic increase of the species in under study. To quantify top-down controls, I created a summed radiocarbon probability distribution (SPD) intended to monitor shifts in the populations of the apex predator: people. To quantify bottom-up controls, I used a climatic model to estimate average effective moisture, which conditions primary biomass and, consequently conditions productivity in higher trophic levels. To quantify prey reproduction rates, I conducted a literature review to determine the rates of intrinsic increase of relevant taxa from the Birch Creek assemblage. Next, I used Spearman's rho and  $\chi^2$  to seek significant correlations between top-down and bottom-up controls and proxies for human prey processing behavior, diet breadth, and prey age, all collected from the Birch Creek assemblage. Save for a few exceptions, the results of these tests proved non-significant.

In my analyses of the Birch Creek archaeofauna, I detected only seven (out of a possible 28) instances of significant relationships between a faunal variable and an environmental variable. Both the artiodactyl and bison abundance indices correlate

positively (and counterintuitively) with SPD. The remaining five significant relationships involve processing proxies and are largely inconsistent with my predictions. My other avenue of inquiry, prey age, did not produce significant correlations. However,  $\chi^2$  tests indicated significant maturity differences between bison and medium-sized artiodactyls in four phases and between bighorn sheep and pronghorn in two phases. Below, I discuss the shortcomings of the Birch Creek dataset, which I believe to have contributed to the very mixed results obtained by my analyses.

### **Shortcomings of the Birch Creek Data Set**

Birch Creek initially appeared to represent a suitable dataset for testing predictions of optimal foraging models. However, as I investigated further, shortcomings came to light. Small sample sizes, a function of the limited number of occupations, in this case five, resulted in many analyses returning statistically insignificant results. Moreover, I was unable to conduct some planned statistical tests due to insufficient sample sizes. In many cases, the state of the assemblage exacerbated this problem.

Excavated in the late 1960's (Swanson 1972), the Birch Creek assemblage suffers from poor cataloging and the discard of many specimens. Many specimens have unclear proveniences that, at times, prevented me from including them in any analysis. These ambiguous proveniences constrained me to use Swanson's phases for my analyses. This constraint contributed to my problem of small sample sizes. Discard of specimens represents an additional problem, reducing my confidence in all of my analyses. I discuss these problems in detail below and examine their ramifications for my study.

### Small Sample Sizes

Small sample sizes hindered my attempts to find statistically significant relationships within my dataset. Birch Creek as currently organized only contains five occupations (phases), too few to easily establish correlations between archaeofaunal phenomena and environmental variables. Six faunal variables had relationships with environmental variables that received correlation coefficients of 0.7 to 0.8. These relationships could not be considered significant at  $p < 0.05$  due to small sample size. These supposed relationships may be entirely spurious, resulting only from a small and unusual sample. Division of the dataset into additional occupations could have helped this problem. Unfortunately, curators recorded the Birch Creek archaeofauna in a way that makes this strategy impractical.

The proveniences listed in the Idaho Museum of Natural History (IMNH) catalog pose a number of problems. The IMNH catalog lists many proveniences with wide depth ranges rather than specific levels. This meant that I could only assign such specimens to Swanson's phases rather than to specific levels. As discussed above, the division of these phases into additional occupations would have helped to establish significant relationships between faunal and environmental variables. Unfortunately, as I could not generally assign specimens with depth-based proveniences to individual levels, dividing the current phases into additional occupations would greatly decrease the number of specimens available for analyses. Currently, 200 specimens, 3.5 percent of the total assemblage, are already absent from my analyses, as their proveniences are too vague to even place within a phase. An additional 44 percent of the total identified within the

IMNH catalog were discarded prior to my examination of the collection. The exclusion of these specimens would only worsen the problems of discarded specimens.

Birch Creek also provided inadequate samples for intra-assemblage analyses. Many of Birch Creek's phases did not contain enough specimens for planned statistical tests, particularly of prey maturity. For example, Phase I lacks enough artiodactyl specimens to use  $\chi^2$  to determine if the bison population is significantly younger than that of the medium artiodactyls. Far more problematically, Birch Creek lacks enough deer specimens in any phase to use  $\chi^2$  to compare the maturity of deer with that of bighorn sheep or pronghorn. This lack of deer specimens meant that I could only compare pronghorn and bighorn sheep maturity. With only two similar-rank taxa to compare, I ended up with fewer points for comparison than would have been ideal.

#### Poor Curation Practices

Curators discarded almost half of the specimens encountered during the Birch Creek excavation. While I attempted to make use of discard as a proxy for fragmentation, this was no substitute for possession of the missing specimens, which represent 44 percent of the total identified within the Idaho Museum of Natural History catalog. I would have preferred to personally examine these specimens, which would bolster my %Intact, MNI/NISP, %Speciated and %WetBreak processing proxies and potentially alter relative abundance measures. Instead, these discarded specimens decrease my confidence in all metrics for prey abundance, prey processing, and prey age. This loss of confidence constrains my ability to monitor Net Acquisition Rate (NAR) through faunal remains. While I cannot know the actual condition of the discarded

specimens, the vast quantity of discarded specimens likely bias my results. In general, I assume that my analyses of the Birch Creek assemblage underestimate both overall fragmentation and the presence of small fauna. In a more general discussion of my analyses, I consider other possible conclusions about these discarded specimens.

### **General Discussion of Birch Creek Results**

My analyses of the Birch Creek archaeofauna produced mixed results. In fact, my analyses contradicted more of my predictions than otherwise. The use of prey age to monitor top-down resource depression, while established in other contexts (Anderson 1981; Broughton 1994, 1997, 2002; Caughley 1966, 1977; Klein and Cruz-Urbe 1984; Lyman 1987) did not yield significant results in this case. In other words, my research failed to find the expected inverse relationship between human population sizes, as measured by SPD, and high-ranked prey abundance. Instead, I detected evidence of a positive relationship between the two variables. Similarly, my analyses of processing intensity generally failed to find correlations between processing proxies and environmental variables. In most cases, the processing proxies that do correlate with environmental variables contradict my expectations. The relative ages of species from the Birch Creek dataset provided one set of positive tests. Slower reproducing, higher-ranked taxa were often represented by younger individuals. I discuss these results in more detail below, and explore possible explanations for the widespread failure of my predictions.

### Resource Depression

My  $\chi^2$  tests of artiodactyl epiphyseal fusion distributions yielded support for the predicted relationship between prey rank and prey age. In all four phases with adequate specimens for fusion comparison, bison populations were younger than medium artiodactyls populations. This finding is consistent with my expectation that, as bison are higher-ranked, and reproduce slower than medium sized prey, predation should lead to younger bison populations. However, without a significant negative correlation between ScoreMature and SPD, I cannot confidently attribute these younger bison populations solely to human predation. The results of these  $\chi^2$  tests are, however, a useful point of comparison between the FPE and prey models.

My  $\chi^2$  analyses of pronghorn and bighorn sheep epiphyseal fusion rates produced inconsistent results. Of the four tests conducted, two indicated no statistical difference, while pronghorn were older in the third test and younger in the fourth. These results indicate that differences in bighorn sheep and pronghorn reproductive rates did not affect top-down abundance depression of similarly-ranked prey. Unlike my other analyses, the FPE and the prey model made different predictions about the relative ages of similarly ranked prey. The FPE model predicts that quicker-reproducing pronghorn should be more resistant to predation than the slower-reproducing sheep. Bighorn sheep populations should thus be younger than pronghorn, assuming similar hunting pressures apply to both populations. In contrast, the prey model, does not consider reproductive rate, and instead predicts no such distinction for top-down control of similarly ranked prey. As Birch Creek's pronghorn are not consistently older than its bighorn sheep, these data fail to support the FPE model's predictions. This failure may result from sample



size. Alternatively, the difference between bighorn sheep (0.35, Cole 1954) and pronghorn (0.48 – 0.45, Cole 1954; Singer and Norland 1994) intrinsic rates of increase may be too small to mediate top-down population depression.

Consistent with both model's expectations,  $\chi^2$  uniformly indicates that higher ranked, slower reproducing bison exhibit more evidence of top-down abundance limitation than do lower-ranked, faster reproducing medium-sized artiodactyls. Comparison of medium-ranked prey ages contradicted the FPE model's predictions, while also supporting the standard prey model. Given the small sample sizes available in this study, these results are not definitive evidence that prey reproductive rate does not influence foraging behavior. Even if presently unproven, the FPE model made an important contribution to this study by prompting my attempts to differentiate the effects of human predation on prey demography.

### Abundance

Prey abundance patterns at Birch Creek contradict the expectations of the FPE and prey models. SPD correlated with high-ranked prey taxa abundance, while modeled effective moisture did not. Contrary to my predictions, evidence from Birch Creek indicates more high-ranked prey in phases with higher human populations. Both the artiodactyl ( $r_s = 0.9$ ,  $p = 0.04$ ) and bison ( $r_s = 0.9$ ,  $p = 0.04$ ) indices indicate positive relationships with SPD. This result indicates that increases in Idaho's human population did not come at the expense of lower NAR, at least as monitored by large-bodied mammal abundance. Indeed, it seems possible that the apparent human population increase seen in the radiocarbon record results from a greater availability of high-ranked

prey. Unfortunately, given the coarse temporal resolution of the Birch Creek materials, I have little confidence in the environmental variables that I use to characterize the conditions under which each phase's faunal assemblage formed. There is little that I can do to disentangle the causal relationships at work in this case.

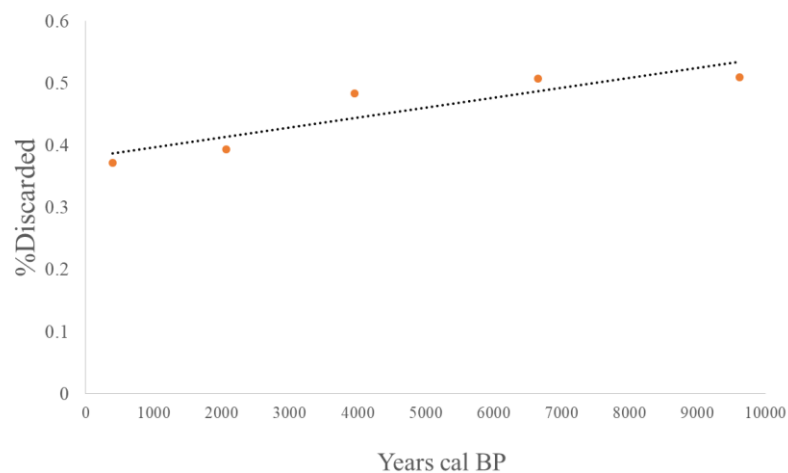
### Measures of Processing Intensity

My analyses of relationships between processing intensity and environmental conditions contradicted my predictions. In this case, increased human population seems to accompany reductions in processing intensity, while decreased effective moisture seems to correlate with decreased processing intensity. Below, I discuss these relationships in detail, processing proxies and human demography.

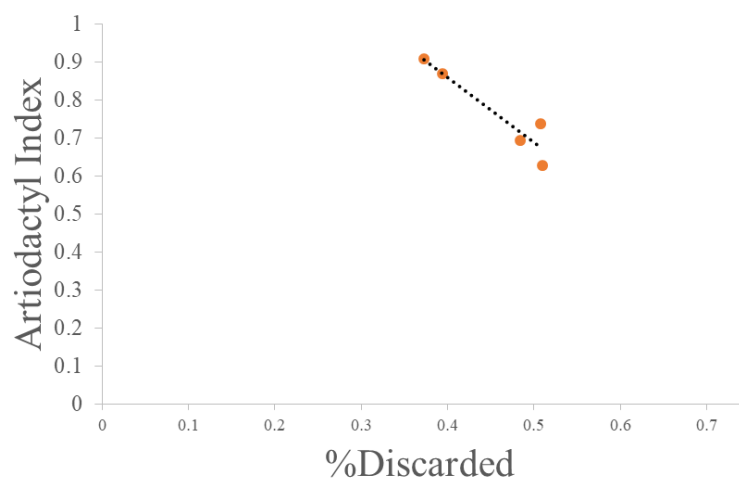
Within the context of my thesis, I expected that larger human populations would exert more hunting pressure on prey populations. As prey become less available, foragers should process their prey more heavily. This behavior should result in assemblages with fewer intact elements and greater discard of potentially unidentifiable specimens by excavators. Both phenomena should ultimately result from more intensive nutrient extraction behavior. My results contradict this pattern. Instead, I found that larger human populations correspond with more intact bison specimens and fewer discarded specimens. Three processing proxies, %Intact Bison, MNI/NISP, and %Discarded, correlate significantly with SPD. %Intact Bison and %Discarded both indicate reduced processing intensity when human populations are largest; %Intact Bison correlates positively with SPD, while %Discarded correlates negatively. MNI/NISP correlates negatively with SPD; this relationship indicates increased processing of prey

when human populations are high. Taken together, these correlations indicate behaviors contrary to my expectations.

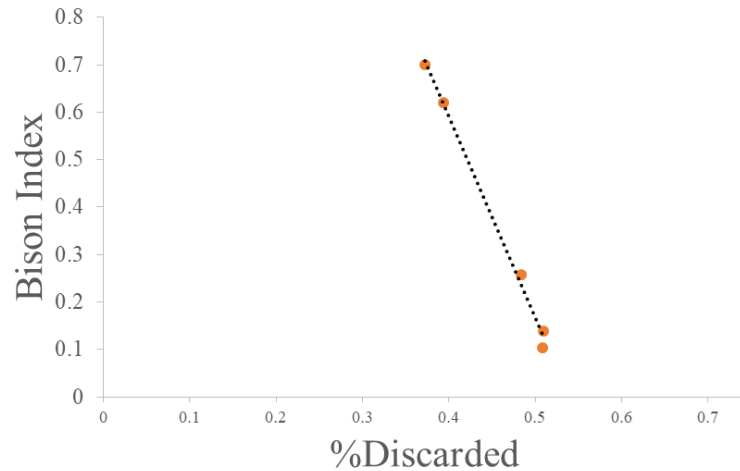
While the aforementioned correlations may result from behavioral processes, the correlation of processing proxies with SPD may instead result from excavator discard decisions, not from foragers' processing decisions. Indeed, as Figure 7.1 shows, %Discarded correlates positively with radiocarbon years cal BP ( $r_s = 1, p = 0$ ). This means that the oldest phases were likely the most fragmentary and specimens from them were discarded at higher rates, while the youngest phases were less fragmentary, resulting in fewer discarded specimens. If Swanson primarily discarded unidentifiable, fragmentary specimens, this relationship means that the oldest phases contained the most fragmentary assemblages. Alternatively, %Discarded may instead be related to the species represented within the assemblage. The artiodactyl ( $r_s = -0.9, p = 0.04$ ) and bison ( $r_s = -0.9, p = 0.04$ ) indices both correlate negatively with %Discarded (Figures 7.2 and 7.3). Assuming equal fragmentation is present for all prey species, more bone fragments from larger prey should remain identifiable. Assuming again that discarded specimens were primarily unidentifiable bone fragments, rates of discard may indicate greater usage of small game in the phases with the most discarded specimens. Conversely, %Intact Bison does not significantly correlate with radiocarbon years cal BP ( $r_s = 0.1, p = 0.87$ ). As such, I regard the negative association of bison fragmentation with SPD to result from causes other than a solely time-based taphonomic bias. If %Intact Bison truly signals increased processing intensity, its positive correlation with SPD may reflect improved access to prey that, in turn, facilitated human population growth. In such a case, SPD would represent a dependent, rather than independent variable.



**Figure 0.1.** %Discarded plotted against radiocarbon years cal BP.



**Figure 0.2.** %Discarded plotted against the Artiodactyl Index.



**Figure 0.3.** %Discarded plotted against the Bison Index.

MNI/NISP also correlates negatively with SPD ( $r_s = -0.9$ ,  $p = 0.04$ ). This relationship indicates that individual animals are typically represented by more specimens in phases with larger human populations. This metric is broadly consistent with the premise that denser human populations will process prey remains more intensively, when one assumes that the search for within-bone nutrients will generate more fractured specimens. Unfortunately, Swanson's liberal discard of specimens likely means that my cataloging efforts did not capture these processing-generated fragments. Given this conclusion, in combination with those offered previously, the Birch Creek assemblage appears incapable of answering questions about the relationship between human population and the processing of prey.

I encountered similar difficulties in identifying a relationship between climate and processing intensity. In this case, however, I found evidence for a positive relationship between modeled effective moisture and processing intensity. In other words, as conditions became more mesic and, consequently more favorable to artiodactyls, processing intensity increased as well. The processing proxies %WetBreak All

Specimens ( $r_s = -0.9$ ,  $p = 0.04$ ) and %WetBreak Medium Artiodactyls ( $r_s = -0.9$ ,  $p = 0.04$ ) both correlate positively with effective moisture. I consider the %WetBreak measures to be my best proxies for processing intensity as they rely on wet bone breakage (Haynes 1983; Johnson 1985), which should only occur near time of death. Non-cultural taphonomic processes should therefore, less affect them than my other proxies. As such, I regard the relationship between average effective moisture and both %WetBreak measures to indicate a real negative correlation between processing intensity and the phases characterized by more effective moisture. This correlation may result, however, from the wide ranges of dates and attendant effective moisture values used to characterize the five Birch Creek phases. As Table 7.1 shows, effective moisture variability within phases generally exceeds effective moisture variability between phases. As such, the correlation between %WetBreak and effective moisture is insufficient evidence to refute the expectations that rising effective moisture should correspond to reduced processing intensity. Instead, this study most likely failed to capture the variables responsible for driving the increase in processing intensity.

My attempts to analyze the relationship between my proxies for carcass processing intensity and environmental conditions produced results that contradicted my expectations. To take these results at face value, one would conclude that larger human populations, especially in drier climates, invest less effort in nutrient extraction. I, however, interpret these analyses to indicate the problems of the Birch Creek dataset are too great for the site to be useful for studying processing intensity. Given extensive specimen discard and overly broad phases, the collection lacks the integrity to disprove the validity of expectations derived from either the FPE or the prey model.

**Table 0-1.** Effective Moisture and Summed Radiocarbon Probability Ranges and Averages by Phase.

Phase	Effective Moisture (cm)		Summed Radiocarbon Probability	
	Average	Range	Average	Range
I	244.19	22.99	0.00012	0.00030
II	215.66	62.66	0.00026	0.00065
III	189.23	34.81	0.00044	0.00059
IV	189.25	36.39	0.00057	0.00121
V	196.56	9.18	0.00129	0.00192

## Implications

This study's inconclusive results provide little evidence to evaluate either foraging models or the SRP's prehistory. Close inspection of these results instead indicate the Birch Creek archaeofauna as unsuitable for studying these problems. Future studies of either topic require more data. These data would be best obtained from complete collections with tight proveniences. If it were practical to divide Swanson's phases into more discrete occupations, i.e. more data points, matters would improve in two ways. First, the environmental conditions under which the faunal remains were deposited would be more accurately modeled. Second, additional data points would enable the establishment of more significant correlations. Unfortunately, such an endeavor appears effectively unworkable. The Birch Creek dataset did yield interesting, and possibly valid results about prey maturity, representing one bright spot in this study. The finding that bison populations are significantly younger than medium-ranked artiodactyls in every phase with testable assemblages is consistent with my predictions.

Moreover, this phenomenon could be investigated in other assemblages containing differently ranked fauna in sufficient quantities.

The addition of archaeofaunas from other SRP sites would help to better realize the aims of this study. This practice would add more data points with which to analyze relationships between foraging behavior and the environmental factors of effective moisture and human demography. Additionally, the use of sites excavated according to modern standards would greatly improve researchers' ability to monitor interplay between environmental conditions and foraging behavior. Archaeofaunal collections that have not been subject to rampant discard could provide more accurate data on both dietary composition and processing intensity than can the Birch Creek collection. Finally, expanded, comparable maturity data for additional taxa, from comparable environments is crucial to evaluating the value of including prey reproductive rates in foraging models.

## **Conclusion**

This thesis represents an attempt to integrate the study of prey population dynamics with the prey model commonly used in optimal foraging theory. To do so, I made predictions about the Birch Creek archaeofauna based on both NAR and rate of intrinsic increase. The assumptions of the FPE model, which extends the assumptions of the prey model to include the reproductive rates of prey, framed these predictions. In this chapter, I discussed my attempt to evaluate the FPE and prey models with the Birch Creek archaeofauna. I first explored the shortcomings of the Birch Creek assemblage.



These include, imprecise dating of components, and the discard of many poorly recorded specimens. Unfortunately, I had to conclude that Birch Creek is not, on its own, suited to distinguishing between the utility of the FPE and prey models. As such, I was unable to confidently endorse one model over the other, mostly due to the inadequacies of my dataset. Presently, I hesitantly endorse the prey model, as it is the more parsimonious of the models, and I lack evidence for resource depression effects mediated solely by  $r$ -value. The most important lesson of this study is need for a better dataset.

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## APPENDICES

## APPENDIX A: IDAHO RADIOCARBON DATES

**Table A.1**

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
UCIAMS-122179	10OA275	Rock Creek	Bison bone	-20.1	AMS		340	15	Arkush 2002
UCIAMS-122182	10OA275	Rock Creek	Bison bone	-20.2	AMS		350	15	Arkush 2002
UCIAMS-122184	10OA275	Rock Creek	Bison bone	-20.4	AMS		910	15	Arkush 2002
UCIAMS-122178	10OA275	Rock Creek	Pronghorn bone	-18.9	AMS		380	15	Arkush 2002
UCIAMS-122181	10OA275	Rock Creek	Pronghorn bone	-18.3	AMS		685	15	Arkush 2002
PRI-10-162	10OA275	West Fork Rock Creek	GSL Gray ceramic residue	-20.3	AMS		780	15	Arkush 2002
PRI-10-69-122	10IH3337		mammal bone				630	20	Root and Ferguson 2010
PRI-10-69-144	10IH3337		mammal bone		AMS		560	20	Root and Ferguson 2010
UCIAMS-122175	10OA275	Rock Creek	Bison bone	-20.0	AMS		690	20	Arkush 2002
UCI-AMS-87906	10WN469	Hetrick	Medium mammal juvenile scapula		AMS		110	20	Manning 2011:25
AA97617	10BT676	Pioneer Site	Bone		AMS		716	25	Keene 2005: 18, 44
UGA-17349	10IH1892	Deep Gully	mammal bone bioapetite		AMS		5540	25	Osterkamp et al. 2014
PRI-10-69-1	10IH3337		charred organic residue from ceramic sherd				580	25	Root and Ferguson 2010
CAIS-2524	10OE1691		musselshell (reservoir corrected)				1800	30	Green 1993
UCI-AMS-87907	10WN469	Hetrick	Medium mammal unidentified		AMS		9830	30	Manning 2011:25
UCI-AMS-87908	10WN469	Hetrick	Medium mammal long bone shaft fragment		AMS		9835	35	Manning 2011:25

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
AA97613	10BT676	Pioneer Site	Bone		AMS		3532	37	Keene 2005: 18, 44
AA97624	10BT676	Pioneer Site	Bone		AMS		3570	38	Keene 2005: 18, 44
Beta-262227	10IH579	Heckman Ranch	bone collagen		AMS		3400	40	Carlini 2011:52
Beta-227323	10MO84	Rexburg Man	bone collagen				1700	40	CARD 2018
Beta-158258	10LN267	Fortress Cave	Wapiti bone collagen		AMS		1430	40	Henrikson 2003
Beta-286102	10EL438		Charred material		AMS		450	40	Plew and Willson 2011
Beta-225737	10EL217	Bancroft Springs	charred material		AMS		350	40	Lohse 2013:15
Beta-198272	10NP453	Five Eagles	Charred material		AMS		7980	40	Ridenour 2006: 97
Beta-262226	10IH579	Heckman Ranch	charred material		AMS		2960	40	Carlini 2011:52
Beta-240236	10NP464	Big Cougar Creek	charred plant				1600	40	CARD 2018
Beta-136050	10LE75	Kittle Rockshelter	Charred plant		AMS		7330	40	Herbel 2001
Beta-199271	10LE34		Charred plant material,	-29.6	AMS		2760	40	CARD 2018
CAIS-2276	10OE60	Givens Hot Springs	musselshell (reservoir corrected)				1150	40	Green 1993
CAIS-2520	10OE1689	Givens Hot Springs	musselshell (reservoir corrected)				4000	40	Green 1993
CAIS-2521	10OE1689	Givens Hot Springs	musselshell (reservoir corrected)				4000	40	Green 1993
Beta-136189	10OA210	Rock Springs	bison long bone fragments		AMS		820	40	Arkush 2000:34
Beta-136190	10OA210	Rock Springs	bison long bone fragments		AMS		840	40	Arkush 2000:34
Beta-216068	10OA20	Bissell Spring	Bone				420	40	Arkush 2006
Beta-169477	10OA272	Peterson Spring	Bone				3080	40	Arkush 2003
Beta-190353	10NP453	Five Eagles	Bone collagen		AMS		8910	40	Ridenour 2006: 97
Beta-197310	10CN6	One Eye Lizard Terrace	Charred Material				620	40	Hill 2006
Beta-201429	10KA425		charred plant	-28.5	AMS		1280	40	Hicks et al. 2006

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
Beta-201430	10BW198		charred plant	-25.5	AMS		400	40	Hicks et al. 2006
Beta-201434	10BW199		Charred plant	-24.6	AMS		1640	40	Hicks et al. 2006
Beta-201436	10BW201		charred plant	-25.8	AMS		1830	40	Hicks et al. 2006
Beta-201441	10BW209		charred plant	-24.8	AMS		1880	40	Hicks et al. 2006
Beta-201443	10BW209		charred plant	-25.0	AMS		1940	40	Hicks et al. 2006
Beta-201445	10BW209		charred plant	-27.3	AMS		4060	40	Hicks et al. 2006
Beta-201446	10BW209		charred plant	-26.4	AMS		4170	40	Hicks et al. 2006
Beta-201447	10BW209		charred plant	-24.6	AMS		4900	40	Hicks et al. 2006
Beta-201442	10BW209		charred plant	-27.2	AMS		1220	40	Hicks et al. 2006
Beta-201444	10BW209		charred plant	-26.4	AMS		3830	40	Hicks et al. 2006
Beta-171261	10CR196	Challis Bison Jump and Kill Site	Puparial cases		Radiometric		900	40	Butler 1971
Beta-287765	10OA275	Rock Creek	Promontory Gray ceramic residue	-23.9	AMS		530	40	Arkush 2002
CAIS-2275	10OE60	Givens Hot Springs	musselshell (reservoir corrected)				1250	40	Green 1993
TX-8236	10IH369	Island Bar Midden	Charred material, charcoal				920	45	Davis 2001
Beta-267424	10CR1231	Harts Creek Cave	sagebrush sandal		AMS		8190	50	Plew and Willson 2010
Beta-262225	10IH579	Heckman Ranch	charred material		AMS		4570	50	Carlini 2011:52
Beta-70363	10IH1017	Upper Landing	charred plant				1710	50	Gallison et al. 1996
Beta-199270	10LE34		charred plant				2720	50	CARD 2018
Beta-190350	10NP453	Five Eagles	Charred plant		AMS		7180	50	Ridenour 2006: 97
Beta-98721	10CA397	Indian Springs	charred plant				190	50	Reid 1997
TX-8080	10IH820	Kam'-nak-ka	charred plant				3299	50	Evans-Janke 1998
CAIS-2268	10OE1689	Givens Hot Springs	musselshell (reservoir corrected)				3800	50	Green 1993



Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
CAIS-2269	10OE1689	Givens Hot Springs	musselshell (reservoir corrected)				4170	50	Green 1993
CAIS-2270	10OE1689	Givens Hot Springs	musselshell (reservoir corrected)				4180	50	Green 1993
Beta-79030	10OA210	Rock Springs	Bison scapula		AMS		370	50	Arkush 2000:34
Beta-201440	10BW209		charred plant	-25.3	Radiometric		520	50	Hicks et al. 2006
Beta-80170	10IH699	Kirkwood Bar	Charred plant				6740	50	Reid and Gallison 1996
CAMS-72240	10BT1	Little Lost River Cave No. 1	Organics				2990	50	Steelman et al. 2002
CAMS-59588	10FR	Franklin peccary	Peccary bone collagen				11340	50	McDonald, 2002
AA97614	10BT676	Pioneer Site	Bone		AMS		3512	53	Keene 2005: 18, 44
AA97615	10BT676	Pioneer Site	Bone		AMS		3778	53	Keene 2005: 18, 44
AA97622	10BT676	Pioneer Site	Bone		AMS		3529	53	Keene 2005: 18, 44
TX-8238		Island Bar Midden	soil extract; extrait de sol				3695	55	Davis 2001
Beta-119622	10JE47	Milner Rockshelter	pronghorn mandible				5310	60	Yohe 2002:27
Beta-33817	10IH1017	Upper Landing	Charred plant				560	60	Draper 1991
Beta-25074	10BV93		bison astragulus and calcaneus				4260	60	Gough 1990:62
Beta-79031	10OA210	Rock Springs	Bison femur		AMS		50	60	Arkush 2000
Beta-79029	10OA210	Rock Springs	Bison metacarpal		AMS		800	60	Arkush 2000
Beta-216069	10OA20	Bissell Spring	Bone				0	60	Arkush 2006
WSU-3426	10AM193	DeMoss	human bone collagen; collagène osseux humaine				5965	60	Green et al. 1986
Beta-61101	10IH699	Kirkwood Bar	Charred plant				7100	60	Reid and Gallison 1996
Beta-68175	10IH699	Kirkwood Bar	Charred plant				6850	60	Reid and Gallison 1996
Beta-38447	10IH1017	Upper Landing	charred plant				1620	60	Gallison et al. 1996; Reid 1996
Beta-126534	10OE240	Schellbach Cave	Twig				2660	60	Pengilly and Yohe 2012:29

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
Beta-70362	10IH1017	Upper Landing	charred plant				1620	70	CARD 2018
TX-5776	10CW4	Clearwater Fish Hatchery	Housepit				2980	70	CARD 2018
TX-6949	10CW4	Clearwater Fish Hatchery	Housepit				1260	70	CARD 2018
TX-6952	10CW4	Clearwater Fish Hatchery	Housepit				1280	70	CARD 2018
TX-6954	10CW4	Clearwater Fish Hatchery	Housepit				1310	70	CARD 2018
TX-6956	10CW4	Clearwater Fish Hatchery	Housepit				1250	70	CARD 2018
TX-6957	10CW4	Clearwater Fish Hatchery	Housepit				1570	70	CARD 2018
TX-9313	10IH820	Kam'-nak-ka	Sediment				860	70	Evans-Janke 1998
Beta-75710	10OE269	Bonus Cove Ranch	mussel shell (corrected)				982	70	Yohe and Neitzel 1998:8; Osterkamp et al. 2014
Beta-96956	10BR111	Carr Creek	Yellow pine, twig ends				4240	70	CARD 2018
Beta-97543	10MA143	Scaredy Cat Cave	Ash	-26.8			3810	70	Henrikson 2002:29
Beta-79032	10OA210	Rock Springs	Bison humerus		AMS		730	70	Arkush 2000
Beta-79033	10OA210	Rock Springs	Bison metacarpal		AMS		440	70	Arkush 2000
Beta-76459		Tolo Lake	mammoth bone collagen; collagène osseux de mammouth				4300	70	Miller et al. 1996
Beta-11809	10LH124	Corn Creek	Charred Bark				770	70	Holmer and Ross 1985
Beta-36145	10IH1017	Upper Landing	charred plant				1600	70	Draper 1991; Reid 1996
D-AMS-08156	10IH483	Bernard Creek Rockshelter	Bone				7193	80	CARD 2018
I-12314		Lower Tuana Springs	bone collagen; collagène osseux				950	80	Fawcett 1998
Beta-97548	10MA143	Scaredy Cat Cave	Ash	-25.3			6680	80	Henrikson 2002:29

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
WSU-4961	10FR4	Weston Canyon Rockshelter	Artiodactyl	-18.606	Radiometric	6420+/-80	7099	80	Arkush 1999:23
Beta-79028	10OA210	Rock Springs	Bison radius / ulna		AMS		3320	80	Arkush 2000:34
OxA-922	10LH15	Jaguar Cave	Bone		AMS		3220	80	Gowlett et al. 1987: 146
OxA-923	10LH15	Jaguar Cave	Bone		AMS		940	80	Gowlett et al. 1987: 146
WSU-750	10BV30	Owl Cave/Wasden	Bone		Radiometric		8000	80	Butler 1969, 1978; Dort 1968; Miller and Dort 1978; Butler 1971 (arbitrary 10% error added since not reported)
NA-ID11	10OE1459	Big Bend	Bone collagen				1070	80	Fawcett 1998
I-12203	10GG191	Crutchfield	bone collagen; collagène osseux				700	80	Murphey and Crutchfield 1985; Meatte 1990
I-12431	10GG191	Crutchfield	bone collagen; collagène osseux				2430	80	Murphey and Crutchfield 1985; Meatte 1990
Beta-190351	10NP453	Five Eagles	Charred material		AMS		8910	80	Ridenour 2006: 97
Beta-36801	10IH1017	Upper Landing	charred plant				1660	80	Reid 1996; CARD 2018
Beta-61044	10IH1892	Deep Gully	charred plant				5600	80	CARD 2018
Beta-97545	10MA143	Scaredy Cat Cave	Organic Matter	-25.6			5740	80	Henrikson 2002:29
WSU-1486	10AA68	Dry Creek Rockshelter	bone collagen; collagène osseux				3530	85	Meatte 1990; Webster 1978
I-13670		Crumbling Bank	bone collagen; collagène osseux				2570	90	Fawcett 1998
Beta-90555	10WN117	Braden Burial	Bone				6590	90	Yohe and Pavesic 1996
I-12315	10TF551		bone collagen; collagène osseux				3170	90	Fawcett 1998; Murphey 1985
I-12430	10GG191	Crutchfield	bone collagen; collagène osseux				3560	90	Murphey and Crutchfield 1985; Meatte 1990
I-13697	10OE2873	Point in Skull	bone collagen; collagène osseux				2170	90	Fawcett 1998; Murphey 1985
Beta-80171	10IH699	Kirkwood Bar	Charred plant				6890	90	Reid and Gallison 1996
Beta-43055	10TF1019	Buhl Burial	Human bone collagen	-19.0	AMS		10675	95	Green et al. 1998; Neves and Blum 2000;

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
UW-431	10CR525	Buck Creek Cave	charred dung, wood				1246	100	Chatters 1982:292
CSUB-RWC-5	10AA99	Diversion Dam Cave	matted vegetation				9220	100	Rogers and Yohe 2006:51
WSU-2484	10BV30	Wasden, Owl Cave	Bison bone collagen; collagène osseux de bison		Radiometric		10470	100	Bryan and Tuohy 1999; Butler 1968, 1969; Lundelius et al. 1983; Miller 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988; Plew and Pavesic 1982
Beta-11657	10IH1308	Gill Gulch	Bone				4780	100	Davis and Muehlenbachs 2001
OxA-920	10LH15	Jaguar Cave	Bone collagen		AMS		7380	100	Gowlett et al. 1987: 146
I-13667	10TF542		bone collagen; collagène osseux				3390	100	Fawcett 1998; Murphey 1985
I-13668	10TF561		bone collagen; collagène osseux				3880	100	Fawcett 1998; Murphey 1985
TO-1647	10JE6	Wilson Butte Cave	bone collagen; collagène osseux				16030	100	Browman and Munsell 1969: 250; Butler 1981; Crane and Griffin 1962: 196, 1966: 280; Gruhn 1961, 1965, 1995; Wright 1978: 121
TO-3300	10JE6	Wilson Butte Cave	bone collagen; collagène osseux		AMS		10700	100	Browman and Munsell 1969: 250; Butler 1981; Crane and Griffin 1962: 196, 1966: 280; Gruhn 1961, 1965, 1995; Lundelius et al. 1983; Wright 1978: 121
AA-20277	10BR1156	Clarks Fork	Human femur, collagen		AMS		5930	100	Pennefather-O'Brien and Strezewski 2002
Beta-61045	10IH1892	Deep Gully	charred plant				6090	100	CARD 2018
I-13669	10TF564	Big Leon's Bank	Bone Collagen				4400	110	Fawcett 1998, Murphey 1985
WSU-1574	10AA68	Dry Creek Rockshelter	bone collagen; collagène osseux				3270	110	Meatle 1990; Webster 1978
WSU-2483	10BV30	Wasden, Owl Cave	Bison bone collagen; collagène osseux de bison		Radiometric		9735	115	Bryan and Tuohy 1999; Butler 1968, 1969; Miller, 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988; Plew and Pavesic 1982

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
WSU-1487	10WN117	Braden Burial	human bone collagen; collagène osseux humain				5790	120	Butler 1980; Harten 1980; Roll and Hackenberger 1998
WSU-3498	10IH1639	Lower Pittsburg Landing	charred plant				5140	120	Reid and Gallison 1996; Draper and Reid 1986
M-1447	10BT62	Saw Mill Canyon	Soil		Radiometric		1540	130	Crane and Griffin 1968: 104; Swanson 1969
M-1456	10BT62	Saw Mill Canyon	Soil		Radiometric		1980	130	Crane and Griffin 1968: 104; Swanson 1969
GaK-2454	10NP102	Arrow Beach	Burial				2930	130	
TX-1899	10NP313	Sweetwater Springs	Charred plant		AMS	10401 +/- 151 (Calendric Age calBP)	9189	138	Lyon 2000: 47
M-1450	10BT62	Saw Mill Canyon	Soil		Radiometric		2230	140	Crane and Griffin 1968: 104; Swanson 1969
M-1451	10BT62	Saw Mill Canyon	Soil		Radiometric		2640	140	Crane and Griffin 1968: 104; Swanson 1969
I-12317	10TF534	Upper Tuana Springs	bone collagen; collagène osseux				3810	140	Fawcett, 1998; Murphey 1985
TO-1650	10JE6	Wilson Butte Cave	bone collagen; collagène osseux				16000	140	Browman and Munsell 1969: 250; Butler 1981; Crane and Griffin 1962: 196, 1966: 280; Gruhn 1961, 1965, 1995; Wright 1978: 121
UW-430	10CR525	Buck Creek Cave	charred dung				2338	150	Chatters 1982:292
WSU-1831	10CR525	Buck Creek Cave	charred dung, wood				4599	150	Chatters 1982:292
Beta-89262	10LE111	Grove Mammoth	M. Columbi rib fragments				14770	150	Plastino et al. 1996; Plastino 1997
WSU-1281	10BV30	Wasden, Owl Cave	Mammoth bone collagen, charred long bone		Radiometric		12930	150	Bryan and Tuohy 1999; Butler 1968, 1969; Lundelius et al. 1983; Miller 1989; Miller and Dort 1978; Sheppard and Chatters 1976; Stanford 1999; Willig and Aikens 1988

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
WSU-1786	10BV30	Wasden, Owl Cave	mammoth bone collagen; collagène osseux de mammouth		Radiometric		10910	150	Bryan and Tuohy 1999; Butler 1968, 1969; Miller 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988
WSU-2485	10BV30	Wasden, Owl Cave	Bison bone collagen; collagène osseux de bison		Radiometric		10145	170	Bryan and Tuohy 1999; Butler 1968, 1969; Miller 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988; Plew and Pavesic 1982
Beta-109971	10IH73	Cooper's Ferry	bone collagen; collagène osseux		AMS		12020	170	Bryan and Tuohy 1999: 258; Davis and Sisson 1998
TO-7357	10IH73	Coopers Ferry	Bone		AMS		10050	180	Davis and Schweger 2004
M-1452	10BT62	Saw Mill Canyon	Soil		Radiometric		4380	200	Crane and Griffin 1968: 104; Swanson 1969
M-1453	10BT62	Saw Mill Canyon	Soil		Radiometric		4780	200	Crane and Griffin 1968: 104; Swanson 1969
WSU-1259	10BV30	Wasden, Owl Cave	mammoth bone collagen; collagène osseux de mammouth		Radiometric		12330	200	Bryan and Tuohy 1999; Butler 1968, 1969; Miller, 1989; Miller and Dort 1978; Sheppard and Chatters 1976; Stanford 1999; Willig and Aikens 1988
M-1454	10BT62	Saw Mill Canyon	Soil		Radiometric		6540	230	Crane and Griffin 1968: 104; Swanson 1969
TX-8301	10NP313	Sweetwater Springs	Charred plant		AMS		6759	242	Lyon 2000
WSU-560	10BV30	Wasden, Owl Cave	Burned bone; os brûlé		Radiometric		8160	260	Bryan and Tuohy 1999; Butler 1968, 1969; Miller 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988
Beta-10069	10OE1548	Heil Pond	charred plant				10880	260	Murphey 1985
WSU-1070	10LH23	Alpha Rockshelter	bone collagen; collagène osseux				6870	290	Benedict and Olson 1978; Chatters 1968: 486-487; Swanson 1972; Swanson and Sneed 1966
WSU-3497	10IH1639	Lower Pittsburg Landing	(corrected musselshell)				3240	296	Reid and Gallison 1996

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
UGAMS-4456	10WA865	Cache Creek	(corrected) musselshell				6859	296	CARD 2018
WSU-1072	10LH23	Alpha Rockshelter	bone collagen; collagène osseux				6270	300	Benedict and Olson 1978; Chatters 1968: 486-487; Swanson 1972; Swanson and Sneed 1966
W-1853	10BV30	Owl Cave/Wasden	Bone		Radiometric		7100	350	Butler 1969, 1978; Dort 1968; Miller and Dort 1978; Butler 1971
M-1853	10BV30	Wasden, Owl Cave	bone collagen; collagène osseux		Radiometric		7180	350	Bryan and Tuohy 1999; Butler 1968, 1969; Crane and Griffin 1968; Miller 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988
UGAMS-17350	10IH1892	Deep Gully	(corrected musselshell)				6094	382	Cherkinsky 2014
CAIS-3240	10IH1017	Upper Landing	corrected musselshell				2015	382	Reid 1996
M-1455	10BT62	Saw Mill Canyon	Soil		Radiometric		7650	400	Crane and Griffin 1968: 104; Swanson 1969
OxA-921	10LH15	Jaguar Cave	Bone		AMS		23400	450	Gowlett et al., 1987: 146
AA-6833	10BV31	Owl Cave	Charcoal		AMS		10640	85	Bryan and Tuohy 1999; Butler 1968, 1969; Miller 1989; Miller and Dort 1978; Stanford 1999; Willig and Aikens 1988
WSU-135	10BT46	Jackknife Cave	Charcoal		Radiometric		160	135	Berger and Libby 1967; Chatters 1968; Fergusson and Libby 1964; Swanson and Sneed 1971; Wright 1982
WSU-134	10BT46	Jackknife Cave	Charcoal		Radiometric		840	125	Berger and Libby 1967; Chatters 1968; Fergusson and Libby 1964; Swanson and Sneed 1971; Wright 1982
WSU-138	10BT46	Jackknife Cave	Charcoal		Radiometric		380	125	Berger and Libby 1967; Chatters 1968; Fergusson and Libby 1964; Swanson and Sneed 1971; Wright 1982
WSU-136	10BT46	Jackknife Cave	Charcoal		Radiometric		6200	155	Berger and Libby 1967; Chatters 1968; Fergusson and Libby 1964; Swanson and Sneed 1971; Wright 1982

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
Beta-98424	10OE5698	Hardtrigger Creek	Charcoal				1310	70	Yohe and St. Clair 1998
Beta-3902	10AA17	Swan Falls	Charcoal				2310	70	Ames 1982, 1983; Meatte 1990; Green 1993
Beta-53630	10PE20	Royston Burial	charcoal				1050	60	Yohe and St. Clair 1998:222
Beta-53631	10PE20	Royston Burial	Charcoal				850	70	Yohe and St. Clair 1998:222
Beta-201437	10BW202		Charcoal	-26.2	AMS		1100	40	Hicks et al. 2006
SM-1354	10CR196	Challis Bison Jump	Charcoal				1030	159	Butler 1971; Roll and Hackenberger 1998
Beta-03901	10AA17	Swan Falls	Charcoal				660	60	Green 1993
TX-4508	10AA17	Swan Falls	Charcoal				800	70	Green 1993
WSU-1410	10CR201	Redfish Lake Overhang	Charcoal				670	130	Brauner 1976; Sheppard and Chatters 1976: 141; Willig and Aikens 1988: 15
TX-3264	10NP143	Hatwai	Charcoal		Radiometric		3440	110	Ames and Marshall 1980; Ames et al. 1981; Reid 1996; Valastro et al. 1980: 1107-1109, 1988: 220; Willig and Aikens 1988
Beta-11087	10LH124	Corn Creek	charcoal				660		Holmer and Ross 1985
Beta-234456	10CA20	Trapper Cliff Shelter	Charcoal		Radiometric		2140	40	Arkush 2013
Beta-234458	10CA20	Trapper Cliff Shelter	charcoal		Radiometric		1790	50	Arkush 2013:34
Beta-234457	10CA20	Trapper Cliff Shelter	charcoal		Radiometric		1780	50	Arkush 2013:34
CSUB-RWC-4	10AA99	Diversion Dam Cave	charcoal				12380	40	Rogers and Yohe 2006:51
CSUB-RWC-2	10AA99	Diversion Dam Cave	charcoal				11750	280	Rogers and Yohe 2006:51
WSU-1395	10CR201	Redfish Lake Overhang	Charcoal		Radiometric		9860	300	Sheppard and Chatters 1976: 141; Willig and Aikens 1988: 15; Sargeant 1973
n/a-ID9	10LH15	Jaguar Cave	Charcoal		Radiometric		3930	390	Dort 1975: 55



Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
I-n/a-ID1	10LH15	Jaguar Cave	charcoal				10370	350	Anderson 1974; Dort 1975, 1977; Gowlett et al. 1987; Guilday and Adam 1967; Lundelius et al. 1983; Mead and Meltzer, 1984: Table 19.4; Sadek 1965; Sadek-Kooros 1972
GX-395	10LH15	Jaguar Cave	Charcoal				11580	250	Anderson,1974; Browman and Munsell 1969: 250; Gowlett et al., 1987; Guilday and Adam 1967; Miller 1965; Sadek 1965; Sadek-Kooros 1972; Willig and Aikens 1988: 9
WSU-4690	10FR4	Weston Canyon Rockshelter	charcoal	-24.214	Radiometric	3980+/-80	4417	80	Arkush 1999:23
Beta-47869	10LH133	Wend Ranch Rockshelter	charcoal				530	90	CARD 2018
Beta-3400	10LH41	Waterfall Village	Charcoal				750	70	Plew and Pavesic 1982; Wylie et al. 1982. Roll and Hackenberger 1998
RB1-2-16-11-R1	10NP55	Redbird Beach	Charcoal		AMS		764	22	Trosper 2011
TX-3089	10NP143	Hatwai	Charcoal		Radiometric		360	60	Ames and Marshall 1980; Ames et al. 1981; Reid 1996; Valastro et al. 1980: 1107-1109, 1988: 220; Willig and Aikens 1988
TX-7465	10GG1	Bliss	Charcoal				300	50	Meatte 1990; Plew 1997
UCLA-160	10CL10	Veratic Rockshelter, Bison Rockshelter	Charcoal				1580	80	Browman and Munsell 1969: 250; Butler 1981; Chandler et al. 1963: 57; Fergusson and Libby 1963; Swanson 1972: 51; Willig and Aikens 1988: 15; Wright 1982: 153
I-453	10CL10	Veratic Rockshelter, Bison Rockshelter	Charcoal				6925	200	Butler 1981; Fergusson and Libby 1963; Swanson 1972; Willig and Aikens 1988; Wright 1982
	10VY80	Pungo Creek	charcoal				2980	40	Holmer and Ross 1985
Beta-219421	10CA20	Trapper Cliff Shelter	charcoal		Radiometric		250	80	Arkush 2013:34

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
TX-3086	10NP143	Hatwai	Charcoal		Radiometric		9160	230	Ames and Marshall 1980; Ames et al. 1981; Reid 1996; Valastro et al. 1980: 1107-1109, 1988: 220; Willig and Aikens 1988
WSU-1397	10CR201	Redfish Lake Overhang	Charcoal				8060	285	Sheppard and Chatters 1976: 141; Willig and Aikens 1988: 15, Sargeant 1973
TX-3088	10NP143	Hatwai	Charcoal		Radiometric		4120	110	Ames and Marshall 1980; Ames et al. 1981; Reid 1996; Valastro et al. 1980: 1107-1109, 1988: 220; Willig and Aikens 1988
WSU-124	10IH80	Double-house	Charcoal		Radiometric		400	50	Chatters 1968: 485
Beta-97547	10MA143	Scaredy Cat Cave	Charcoal	-24.3			6370	90	Henrikson 2002:29
TX-3266	10NP143	Hatwai	Charcoal		Radiometric		8660	1660	Ames and Marshall 1980; Ames et al. 1981; Reid 1996; Valastro et al. 1980: 1107-1109, 1988: 220; Willig and Aikens 1988
Beta-114948	10IH73	Coopers Ferry	Charcoal		AMS		7300	70	Davis and Schweger 2004
Beta-234455	10CA20	Trapper Cliff Shelter	charcoal from ash lens		Radiometric		270	50	Arkush 2013:34
GX-2131	10CR197	Quill Cave	Charcoal, twigs				1270	90	Butler 1971; Roll and Hackenberger 1998
Beta-114951	10IH73	Cooper's Ferry	charcoal; charbon de bois		AMS		8410	70	Bryan and Tuohy 1999: 258; Davis and Sisson 1998
Beta-114952	10IH73	Coopers Ferry	charcoal; charbon de bois		AMS		8430	70	Bryan and Tuohy 1999: 258; Davis and Sisson 1998
TX-4267	10CA17	Ashtrap Rockshelter	charcoal; charbon de bois				1160	80	Fawcett 1998; Plew and Pavesic 1982; Skinner 1981:22
WSU-1441	10BM50	Poison Creek	charcoal; charbon de bois				450	80	Frison 1982; Plew and Pavesic 1982; Sheppard and Chatters 1976; Wright 1978; Neudorfer 1976; Epperson 1975:3
WSU-126	10IH80	Double-house	charcoal; charbon de bois		Radiometric		modern		Chatters 1968: 485

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
WSU-1478	10BM50	Poison Creek	charcoal; charbon de bois		Radiometric		720	70	Frison 1982; Plew and Pavesic 1982; Sheppard and Chatters 1976; Wright 1978; Neudorfer 1976; Epperson 1975:3
WSU-254	10IH80	Double-house	charcoal; charbon de bois				2040	190	Chatters 1968: 485
TX-4789	10OE60	Givens Hot Springs	charcoal; charbon de bois				1190	70	Meatte, 1990; Reid 1996; Green 1993
TX-4790	10OE60	Givens Hot Springs	charcoal; charbon de bois				1100	60	Meatte 1990; Reid 1996; Green 1993
TX-5728	10OE60	Givens Hot Springs	charcoal; charbon de bois				1270	80	Meatte 1990; Reid 1996; Green 1993
UCLA-220	10CL10	Veratic Rockshelter, Bison Rockshelter	charcoal; charbon de bois				2350	120	Butler 1981; Fergusson and Libby 1963; Swanson 1972; Willig and Aikens 1988; Wright 1982
UCLA-219	10CL10	Veratic Rockshelter, Bison Rockshelter	charcoal; charbon de bois				2960	100	Butler 1981; Fergusson and Libby 1963; Swanson 1972; Willig and Aikens 1988; Wright 1982
UCLA-130	10CL10	Veratic Rockshelter, Bison Rockshelter	charcoal; charbon de bois				3360	100	Butler 1981; Fergusson and Libby 1963; Swanson 1972; Willig and Aikens 1988; Wright 1982
UCLA-161	10CL10	Veratic Rockshelter, Bison Rockshelter	charcoal; charbon de bois				5870	120	Browman and Munsell 1969: 250; Butler 1981; Chandler et al. 1963: 57; Fergusson and Libby 1963: 2; Swanson 1972: 51; Willig and Aikens 1988: 15; Wright 1982: 153
WSU-2503	10AA68	Dry Creek Rockshelter	charcoal; charbon de bois				2090	80	Meatte 1990; Webster 1978;
WSU-1513	10AA68	Dry Creek Rockshelter	charcoal; charbon de bois				1410	70	Meatte 1990; Webster 1978
WSU-1514	10AA68	Dry Creek Rockshelter	charcoal; charbon de bois				1710	75	Meatte 1990; Webster 1978

Lab-Number	Site Number	Site Name	Material Details	13C/12C	AMS or Radiometric	Measured Age	Conventional (normalized) Date (mean)	Conventional date (error)	REFERENCE
Beta-3901	10AA17	Swan Falls	charcoal; charbon de bois				650	60	Meatte 1990
TX-4509	10AA17	Swan Falls	charcoal; charbon de bois				1470	60	Meatte 1990; Ames 1983
WSU-253	10IH80	Double-house	charcoal; charbon de bois		Radiometric		280	140	Chatters 1968: 485
TX-4268	10CA17	Ashtrap Rockshelter	charcoal; charbon de bois				1230	80	Plew and Pavesic 1982; Skinner 1981:22
UCLA-252	10CL100	unnamed rockshelter	charcoal; charbon de bois		Radiometric		1420	80	Fergusson and Libby 1964; Plew and Pavesic 1982; Swanson et al. 1964; Wright 1982
UCLA-253	10CL100	unnamed rockshelter	charcoal; charbon de bois		Radiometric		365	80	Fergusson and Libby 1964; Plew and Pavesic 1982; Swanson et al. 1964; Wright 1982
WSU-137	10CL23	Cottontail Rockshelter	charcoal; charbon de bois		Radiometric	4420+/-145			Chatters 1968: 485-486; Swanson et al. 1964; Wright 1982
UCLA-254	10CL100	unnamed rockshelter	charcoal; charbon de bois		Radiometric		1820	80	Fergusson and Libby 1964; Plew and Pavesic 1982; Swanson et al. 1964; Wright 1982
UCLA-255	10CL100	unnamed rockshelter	charcoal; charbon de bois		Radiometric		4500	100	Fergusson and Libby 1964; Plew and Pavesic 1982; Swanson et al. 1964; Wright 1982
UCLA-256	10CL100	unnamed rockshelter	charcoal; charbon de bois		Radiometric		3170	80	Fergusson and Libby, 1964; Plew and Pavesic 1982; Swanson et al. 1964; Wright 1982
WSU-2403	10CW41	Elk Creek	charcoal; charbon de bois				2970	90	Mattson 1983: 56
WSU-2404	10CW41	Elk Creek	charcoal; charbon de bois				1910	90	Mattson 1983: 56
Beta-124446	10NP336	Wewukiyehpuh	Hearth charcoal				10270	50	Sappington and Schuknecht-McDaniel 2001

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