University of Nevada, Reno

The Weed Lake Ditch Site: An Early Holocene Occupation on the Shore of Pluvial Lake Malheur, Harney Basin, Oregon.

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Arts in
Anthropology

by

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ABSTRACT

The establishment of chronologies of environmental and archaeological changes in the early Holocene is essential for understanding how people adapted to dramatic climate changes. The reliance in the Great Basin upon rare well-stratified caves to establish these sequences may lead to their overrepresentation in the interpretation of landscape use, artifact assemblages, and subsistence strategies. The Weed Lake Ditch site is one of the few well-stratified open sites excavated that date to the early Holocene. Haskett Stemmed projectile points, a Crescent, and a rare bone-bead preform have been recovered from the site, in addition to a large lithic assemblage and associated faunal remains. The project has provided information allowing the reconstruction of lake levels, environmental context, subsistence strategies, season of occupation, its age of occupation, and proof that people inhabited the *active* shoreline of Pluvial Lake Malheur.

ACKNOWLEDGEMENTS

This project would not have been possible without the assistance and support of many people, only a few of which are mentioned below. To all of them I offer my thanks. I owe many of the ideas represented herein to discussions with those that follow, however, any errors are my own.

I owe special thanks to Fred Nials for first introducing me to geoarchaeology and the Sundance Archaeological Research Fund at UNR. His patience in answering my never-ending questions is much appreciated, as is his willingness to share his wisdom of Great Basin geomorphology and archaeology. His songs and stories always make me smile and made being bombarded by sand in the trenches bearable. Also, his descriptions and interpretations of the excavation and backhoe trench stratigraphic profiles are key to my conclusions drawn herein.

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The work on the Malheur National Wildlife Refuge would not have been possible without the help of Carla Burnside, who found a backhoe and operator with little notice. She also provided aerial photos and landsat images that were very useful.

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CHAPTER 1: INTRODUCTION

The interplay between culture and environment is of interest to archaeologists using ecological modeling to understand mobility and subsistence patterns of prehistoric peoples. In using these models, it is of utmost importance to have detailed information on the environmental resources available for utilization. This knowledge can be difficult to ascertain for periods of volatile climatic changes such as occurred at the late Pleistocene and early Holocene transition in the Great Basin, when once expansive lakes declined rapidly as the glaciers retreated northward, and the plant and animal communities reorganized as each species individually responded to the new conditions or perished.

The Weed Lake Ditch site has provided a dated environmental sequence in association with a Haskett Tradition archaeological assemblage. This thesis details the material recovered from the archaeological site and attempts to interpret it in the context of the modified environmental sequence of the Harney basin and the Great Basin in general. In addition, I make an effort to describe the possible cultural and technological connections of the High Lava Plains following the end of the Younger Dryas period ca. 10,000 ^{14}C yrs BP in relation to the Haskett Tradition.

The Weed Lake Ditch site (35HA341) is located on the relic shoreline of pluvial Lake Malheur in the Harney Basin of southeastern Oregon (Figure 1). Excavations at the site from 2000 to 2001 revealed a well-stratified early Holocene archaeological assemblage concentrated in one sand and gravel stratum. This cultural stratum has been radiocarbon dated to 9,820 $\pm$ 60 ^{14}C yrs BP (Beta-172010) using gastropod shell.

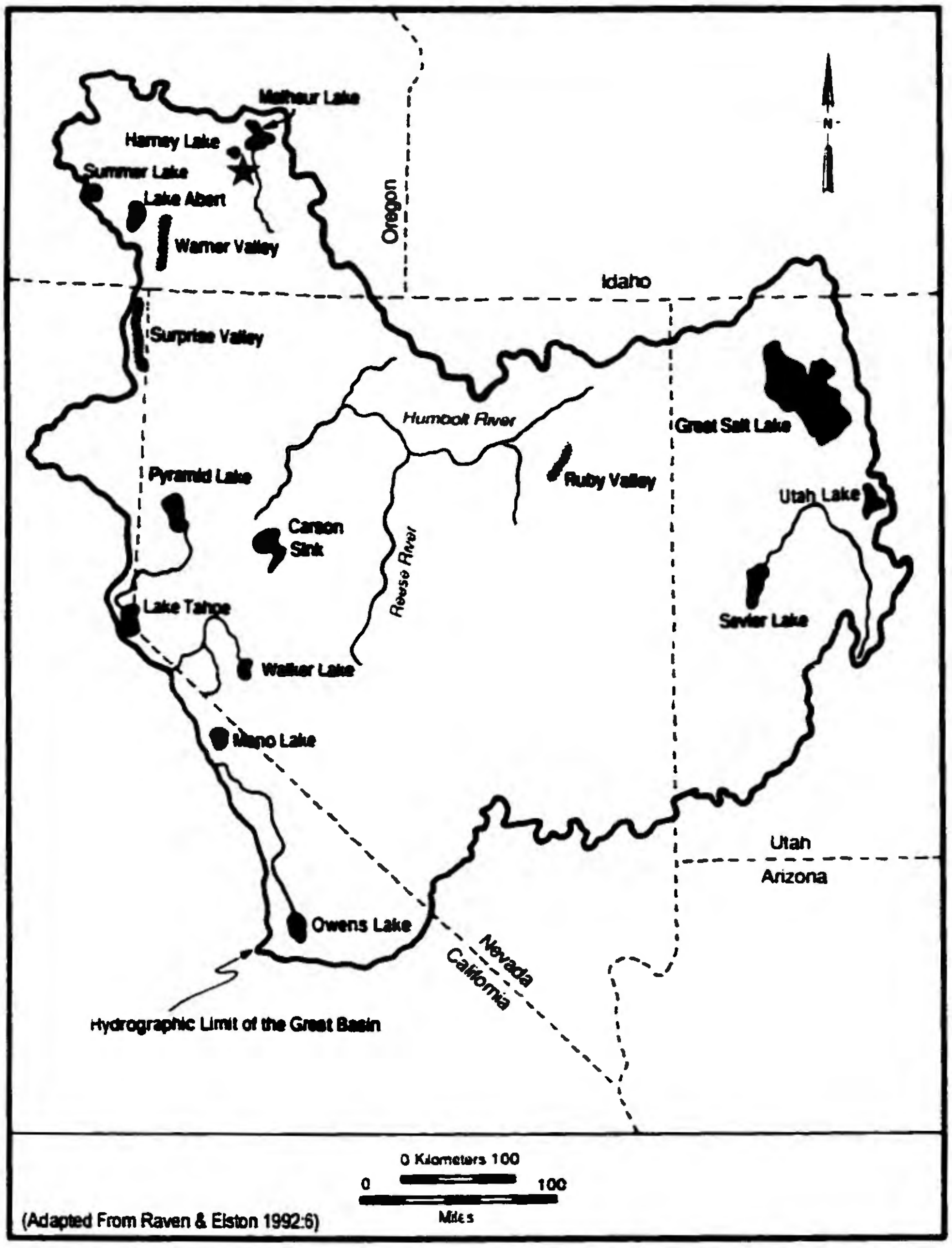


Figure 1. Weed Lake Ditch Project Location (adapted from Raven and Elston 1992:6).

Therefore, this occupation occurred shortly after the last highstand of Pluvial Lake Malheur, for which a revised date of 9,860 ± 80 ^{14}C yrs BP (Beta-161511) has been obtained from gastropod shell during this project.

Investigation of the site ensued after the discovery of a large lanceolate *in situ* Haskett projectile point eroding from the wall of the Weed Lake Drainage Ditch. This

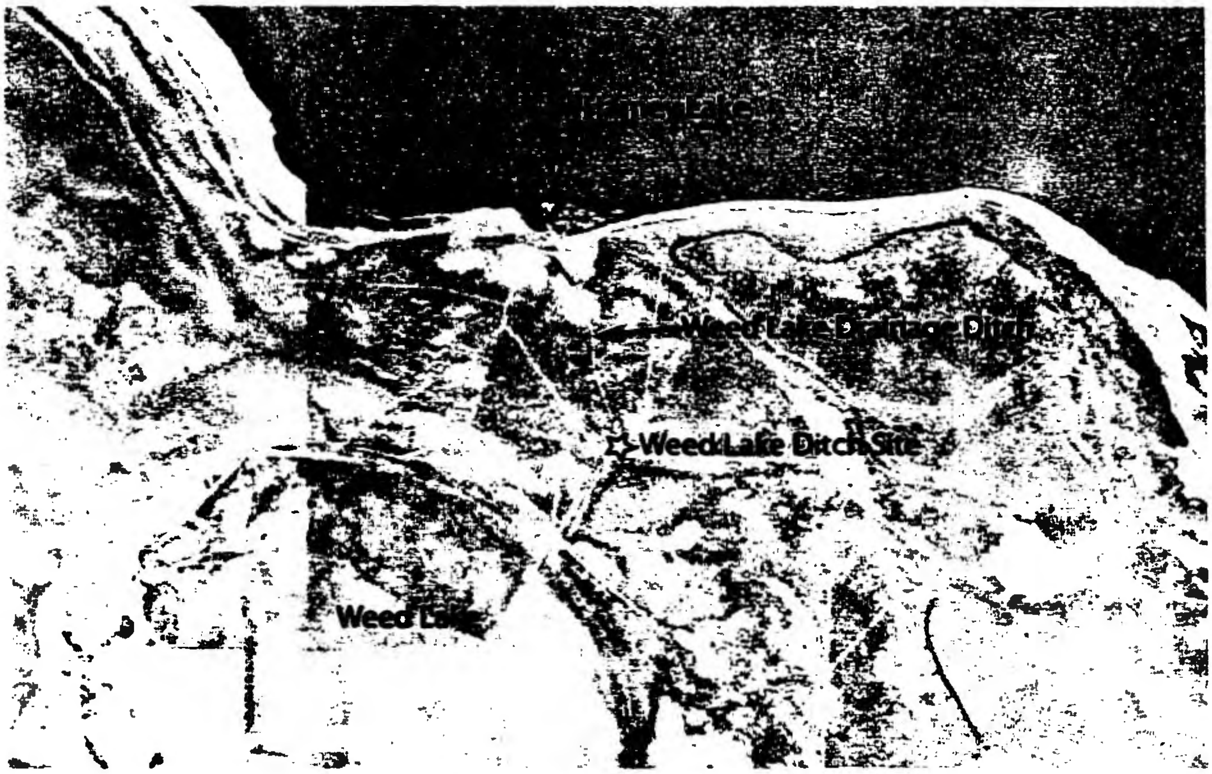


Figure 2. Weed Lake Ditch site location.

large drainage ditch cut, which is nearly one mile long (1.61 km) and up to 12 feet (3.66 m) deep, was excavated in the 1920s (Gehr 1980) in order to drain Weed Lake flat into Harney Lake. This ditch provides a window into the last ca. 32,000 ^{14}C yrs BP of the geologic history of the region (Gehr 1980).

The Weed Lake Ditch site is situated on a gravel-spit bar created by the wave action of Pluvial Lake Malheur (Figure 2). This bar separated Harney Lake and Weed Lake Flat to the south, providing a dam of the ephemeral Jack Ass Creek Drainage coming from the uplands to the south before the ditch provided drainage.

Four Haskett Stemmed projectile points, three untyped Stemmed projectile points, one Crescent, one bone bead preform, 32 bifaces, eight unifaces, seven utilized flakes, 14,504 bone fragments, 33 charcoal samples, 1,482 pieces of gastropod shell, 11 cores, 16,242 pieces of lithic debitage, and 90 other specimens were recovered from the eight 1 x 1 meter units excavated. In addition, a surface survey of just over 400 acres centered on the excavation site recorded over 200 lithic tools, including 53 collected temporally diagnostic artifacts. Of these temporally diagnostic artifacts, early Holocene types predominate with 34 Stemmed projectile points, six Concave Base projectile points, and four Crescents collected. The remaining nine projectile points are either Elko, Rosegate, or unidentifiable.

In addition to the excavations, backhoe trenching and augering provided data for the construction of a stratigraphic profile for the embayment containing the site. This stratigraphic profile helps establish the horizontal and vertical relationships between the dated high shoreline deposits at the edge of the embayment, the Weed Lake Ditch site, nearby marsh and wet meadow deposits, and the cultural stratum of the nearby Biting Fly site (35HA1260). The high shoreline of the pluvial lake is oldest, with the inhabitants of the Weed Lake Ditch site arriving shortly after it began its decline from the sill elevation of 4114 feet (1253.95 m). Marsh and wet meadow persisted on the south side of the gravel bar the site is situated upon until at least 9,540 $\pm$ 60 ^{14}C yrs BP (Beta-172009) based on the radiocarbon assay of a gastropod shell extracted from this wet meadow deposit. The Biting Fly site was inhabited after this period, probably around ca. 8,000 ^{14}C yrs BP (Branigan 2000).

The methods, analyses, and interpretation of the material recovered from the archaeological excavations, surface survey, and backhoe excavation are described in the following chapters.

CHAPTER 2:
ENVIRONMENTAL BACKGROUND

Great Basin

Introduction. Environmental reconstruction of past landscapes and resource distribution is necessary in order to understand how people lived in the Great Basin during the volatile climatic transition of the late Pleistocene to the early Holocene. The pluvial lakes throughout the Great Basin were fluctuating dramatically as the jetstream moved northward during this time, shifting precipitation, cloud-cover, and other factors affecting moisture levels in the lakes. The Younger Dryas, a climatic event affecting the northern hemisphere from ca. 10,900 to 10,000 ^{14}C yrs BP (Grayson 1993; Madsen 1999), gripped the Great Basin in one last cold event before it ended in the early Holocene. The climatic changes following the Younger Dryas are less well understood, but the Great Basin was generally becoming warmer and dryer during the Holocene, interrupted with occasional mesic intervals, particularly during the mid-Holocene.

Environmental Reconstructions. In many ways, the Great Basin is the best of laboratories for studying past climatic conditions (Wigand and Rhode 2002; Morrison 1991). Little sediment is lost out of the hydrographically closed basins, except that which is blown away, and the water levels respond predictably to changes in evaporation, precipitation, and/or temperature (Grayson 1993). In addition, the semi-arid climate affords great preservation potential for pollen, macrofossils, and archaeological organic remains within the many dry caves found throughout the region (Wigand 1990;Wigand and Rhode 2002). Tephra layers, each with a unique chemical signature, provide additional temporally unique markers. The combination of shoreline features (e.g., wavecut scarps, gravel bars, tufa accumulations, etc.), lacustrine and marsh associated identifiers (ostracodes, diatoms, molluscs, tufas, etc.), dateable tephras, woodrat middens, finely stratified lake bottoms, and well preserved archaeological sites, make the Great Basin the ideal subject for paleoenvironmental studies.

The many proxy data available to test hypotheses serve to refine the Great Basin's environmental sequence, which, when compared to the Greenland ice cores that record global cycles of climate change, can provide information on the climatic forcing events that may have induced change within the Great Basin. In this way, it can eventually be determined how and to what extent the inter-basin lake level fluctuations' synchroneity, or lack thereof, were influenced by local, regional, or global systems (Madsen 1999).

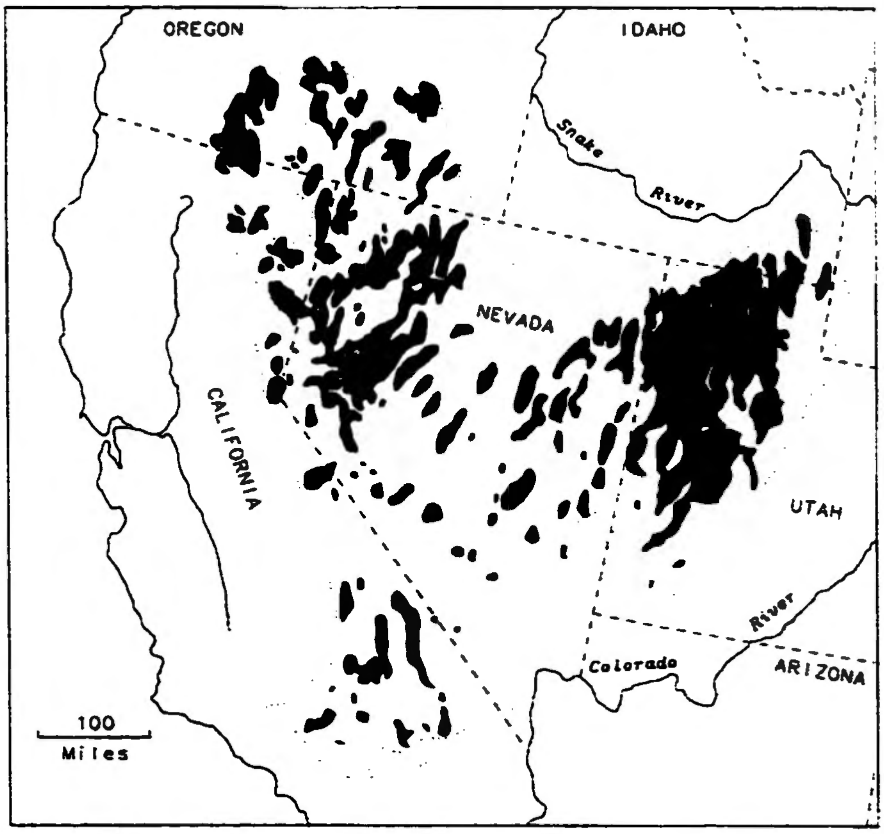


Figure 3. Pluvial Lakes of the Great Basin during the late Pleistocene (from Grayson 1993:86).

The Great Basin consists of more than 150 intermontane sub-basins, separated by approximately 160 roughly north-to-south trending mountain ranges created by extensional tectonics that began around 16 million years ago (Morrison 1991; Cole and Armentrout 1979). The majority of these sub-basins have contained lakes at some point in the past, and approximately 120 pluvial lakes existed during the late Pleistocene (Figure 3; Morrison 1991). During the early Holocene, the pluvial lakes either were completely desiccated or receded substantially. Many theories exist as to what forced the

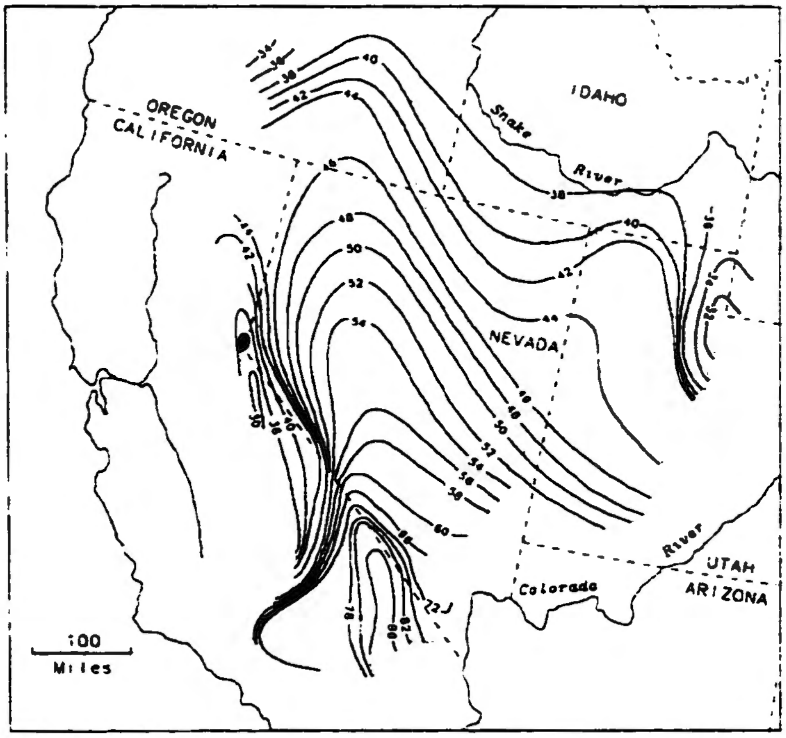


Figure 4, Lake evaporation rates (in inches per year) in the Great Basin. After U.S. Department of Commerce (1983) and from (Grayson 1993:83).

climatic shift that resulted in the demise of these lakes, but greater seasonality, warmer temperatures, and less effective precipitation were responsible for their actual decline.

Only a few semi-permanent lakes remain today, with most occurring near the margins of the Great Basin. The extant semi-permanent lakes of the northwestern Great

Basin include: Malheur Lake, Lake Abert, Goose Lake, Warner Valley, and Summer Lake (Nials 1999a; see also Madsen 1999). These lakes persist for two reasons: (1) because of the winter precipitation brought in by Pacific storms, stored in the form of snowpack in the uplands surrounding them, and then slowly released into the lakes during the spring and summer months; and (2) the generally lower temperatures found at northern latitudes and the resultant decrease in evaporation rates (see Figure 4;Grayson 1993).

The end of the last glacial maximum signaled the beginning of dramatic change for the environment of the Great Basin. Plant communities reorganized as individual species adapted to the changing conditions at varying rates, glacial lakes dried up, and megafauna became extinct along with a variety of smaller species (Grayson 1993). These changes were generally synchronous with the continental glacial retreat in the northern hemisphere. Geologists classify this period as the end of one geologic epoch - the Pleistocene, and the beginning another - the Holocene. In the Great Basin, the once expansive pluvial lakes began to dry. However, these changes, while broadly synchronous across the Great Basin, varied in their timing within each basin due to local or regional factors.

The creation of the large pluvial lakes within the Great Basin was due to relatively low temperatures, highly effective precipitation, and less distinct seasonality (summers were not as hot and dry, and winters not as cold as modern times). The late Pleistocene average annual temperatures were approximately 9° to 13°F colder than present, resulting in lower evaporation rates on the large surface areas of the lakes (Grayson 1993). The forces causing lower temperatures and increased precipitation are still being debated; however, one argument is more readily accepted than others – that the Jet Stream was further south than at present.

> Today, the winter jet stream, which marks the boundary between cold and warm air masses, passes over the west coast of North America at about 50 ° N latitude. Climatic modeling of atmospheric circulation during the late Pleistocene by climatologists John Kutzbach and his colleagues strongly suggests that one effect of the vast northern ice mass was to split the jet stream in two, with one arm skirting the northern edge of that ice, the other swinging far south of it in western North America. One effect of the more southerly location of the jet stream would be to increase the frequency of Pacific storms reaching the Great Basin, bringing both increased precipitation and increased cloud cover [Grayson 1993:98].

This model explains the increased precipitation and lower evaporation rates that would result in the formation of the pluvial lakes.

Following a brief warming period at the end of the Pleistocene, a cold global climatic event called the Younger Dryas caused some of the pluvial lakes to rise to a level below that of the previous highstand. The Younger Dryas is evident in the Greenland ice cores beginning at approximately 10,900 ^{14}C yrs BP and ending abruptly around 10,000 ^{14}C yrs BP (Madsen 1999; Madsen 2000). However, Madsen has proposed a slightly broader timeline for use in Great Basin environmental and archaeological research of between 11,200 $\pm$ 200 ^{14}C yrs BP and 10,100 $\pm$ 200 ^{14}C yrs BP due to radiocarbon calibration curve problems, possible differences in the reservoir effects between lakes, and the fact that the short duration of the event does not allow for statistically valid comparisons in dates of this age (Madsen 1999:77). The Younger Dryas is characterized as having a high degree of climatic volatility, colder and dryer conditions, and greater seasonal equability than present (Madsen 2000). Although dry, the decreased amount of evaporation in the cold conditions allowed another rebound in the pluvial lake levels

(Benson et al. 1990). In the Bonneville basin, Lake Bonneville rebounded to the Gilbert shoreline level slightly after 11,000 ^{14}C yrs BP (Madsen 2000; Grayson 1993; Currey and Oviatt 1985; Benson et al. 1990; Oviatt 1997). In Lake Lahontan, researchers suggest that a rebound at around this time created the Russell shoreline features (Benson et al. 1990; Grayson 1993).

Just as quickly as it began, the Younger Dryas climatic event ended. The rising temperatures led to another decline in the pluvial lakes beginning ca. 10,500 ^{14}C yrs BP. However, moist conditions are evident at many lakes throughout the Great Basin after the end of the Younger Dryas (Grayson 1993; Wigand and Rhode 2002). Therefore, although conditions were dryer than before, they had not yet reached modern levels. Another slight rebound occurred at several lakes around 9,500 ^{14}C yrs BP (see environmental discussion section). Whether this last rebound relates to global climatic cycles or Great Basin regional patterns is not yet known. Madsen has proposed a model that superimposes the Dansgaard-Oeschger 1,500-year cycles upon a larger 20,000-year cycle of solar radiation to explain the late Pleistocene and Holocene lake level fluctuations of the Bonneville Basin. Using the basin overflow levels as the upper boundary, and the basin bottom as the lower boundary, Madsen was able to reflect the timing and intensity of the known Bonneville lake level changes. Interestingly, the model that Madsen outlined predicts a 9800 ^{14}C yrs BP, post-Gilbert rise in lake level, a transgression that is yet to be substantiated (Madsen 2000). However, evidence for this rebound is beginning to accumulate in Bonneville and other basins. Marsh deposits recently identified near Wendover date to this time period (Madsen *cited in* Wigand and Rhode 2002), and many other basins, including Harney, do have highstands that occur at this time (see environmental discussion section). Wigand and Rhode (2002) have suggested that ca. 9,500 ^{14}C yrs BP conditions in the southern Great Basin were generally warmer and wetter, possibly as a result of deeper penetration of monsoons from strengthened westerlies brought about by the thermal maximum. Stronger, or more frequent, successive low-pressure cells during spring and fall could also have served to increase precipitation (Houghton 1969; Benson and Thompson 1987; Dugas 1996), particularly in the northern Great Basin.

A rough chronology of nearly synchronous lake level fluctuations throughout the Great Basin has been established using the largest of the pluvial lakes. However, the environmental chronologies of only a few of the smaller, more responsive basins have been studied. In the past, Lake Bonneville and Lake Lahontan have received the most attention because of the interest in understanding how global climatic cycles were affecting the Great Basin. These lakes were less likely to respond to small-scale changes in effective precipitation. However, now we have reached a point at which we must also understand the small-scale cycles. The smaller basins hold information about small-scale or short-lived patterns that are often undetectable in the Lake Bonneville and Lake Lahontan sequences. A more refined chronologic record of past environmental conditions throughout the Great Basin would benefit both large and small-scale environmental models. This information is necessary if we are to understand the amount of inter-and-intra basin variability that occurred, and how these variations affected the resources available to inhabitants of the Great Basin (Nials 1999a).

Before ca. 8,000 ^{14}C yrs BP, portions of the Great Basin remained moist with shallow lakes and marshes in basin bottoms and uplands with flowing springs and streams. This may have been a period of relative abundance for the hunters and foragers exploiting the rich water-related resources - people who are associated with the Great Basin Stemmed lithic tradition (Beck and Jones 1997). After ca. 8,000 ^{14}C yrs BP the termination of the cool and moist conditions that characterized the early Holocene is evidenced by the faunal record of the northern Great Basin (Grayson 1979), lake deposits from the central basin (Thompson 1992), marsh deposits and pollen records from the northwestern basin (Dugas 1996; Wigand and Mehringer 1985), and the tree-ring records from the southwestern Great Basin (Feng and Epstein 1994; Grayson 1993; Wigand and Rhode 2002). After this period, the Great Basin became more arid with a less volatile climatic regime, greater seasonality, and warmer conditions (Madsen 1999; Madsen 2000; Beck and Jones 1997). By the time Mazama ash fell ca. 6900 ^{14}C yrs BP, the majority of the basins were experiencing severe drought (Wigand and Rhode 2002; Grayson 1993). At this time, aeolian erosive activity dominated the landscape, forming extensive dune fields on the downwind margins of the now dry pluvial lake playas (Wigand and Rhode 2002).

This summarizes the large-scale climatic conditions of the terminal Pleistocene and early Holocene in the Great Basin. However, as previously discussed, finer-grained data are needed in order to interpret the lifeways of past peoples. Regional fluctuations in climate were occurring rapidly during this period and how people adapted to best utilize the resources available is of archaeological interest. To be able to identify the changing resource types and locations of the terminal Pleistocene/early Holocene transition, paleoecologists, geomorphologists, and archaeologists must establish both local and regional chronologies for past landscapes.

The lake levels are the most obvious place to begin a local environmental chronology and establish its relationship to human habitation. The physical characteristics of a basin constrain where water can go in a predictable pattern, where marshes will develop at a given lake level and the best travel routes for humans (Nials 1999). One of the primary goals of the Weed Lake Ditch Project has been to establish when the last highstand of pluvial Lake Malheur occurred and the relationship of this highstand and subsequent environments to the early Holocene occupation of the Weed Lake Ditch site. The available information on the environmental sequence of the Harney Basin is discussed below.

Harney Basin

Introduction. The Harney Basin is located on the northwestern margin of the Great Basin, just south of the interior uplands of the Columbia Plateau. The basin is an area of transition, with forested mountains to the north and shrub-steppe vegetation covering the plateau-and-basin terrain to the south (McDowell 1992).

The region is semi-arid with elevations ranging from 4079 ft (1243 m) on Harney Playa to 9733 ft (2967 m) at the summit of the Steens Mountains (Gehr 1980). The winters are long and severe and the summers relatively short. The average maximum temperature in January is 35.7 °F (2.2 °C), while the maximum average in July is 86.1 °F (30.0 °C). The average minimum temperature in January is 16.3 °F (-8.9 °C), while the average minimum for July is 52.1 °F (11.1 °C). Storms in the winter generally come from the northeast and frequently drop temperatures to below 0 °F (-17.8 °C). The majority of the precipitation falls as snow during the winter months, which normally ranges from a few inches in the valleys to over 70 inches (177.8 cm) in the mountains (State Water Resources Board 1967).

Flora and Fauna. The vegetation of Harney Basin reflects the limitations of its thin, volcanic, often saline soils, and dry climate (Wigand 1987:435) and is dominated by sagebrush steppe and saltbush scrub in the lowlands; occasional oases of Great Basin Wild Rye (*Elymus cinereus)*, bunch grasses, and Currant (*Ribes* spp.) near springs; and uplands dotted with Juniper (*Juniperus* spp.) and shrubs. In the immediate vicinity of the Weed Lake Ditch site, the soil is slightly alkaline and supports greasewood (*Sarcobatus vermiculatus*), occasional saltbush (*Artiplex confertifolia),* big sagebrush (*Artemisia tridentate)*, and a light understory of bunchgrasses. However, during the early Holocene, the soil was probably not as alkaline and the elevated water would have supported an environment similar to the shoreline of Malheur Lake today. Plants supported at Malheur Lake, actually a freshwater marsh, include: emergent aquatic plants such as hardstem bulrush (*Scirpus actutus*), Baltic rush (*Juncus balticus*), bur-reed (*Sparganium eurycarpus*), and cattail (*Typha latifolia*); the open water of the lake supports sago pondweed (*Potamogeton pectinatus*), water-milfoil (*Myriophyllum spicatum*), and horned pondweed (*Zannichellia palustris*); and nearby sandy beach zones are inhabited by greasewood (*Sarcobatus* spp.), salt grass (*Distichilis stricta*), squirreltail (*Sitanion hystrix*), waada (*Suaeda depressa)*, and some Great Basin Wild Rye (*Elymus cinereus)* (Dugas 1996:6).

Probably the most outstanding aspect of the Harney Basin is the sheer abundance of waterfowl found there: over 240 species of water birds visit, nest, or breed at the Malheur National Wildlife Refuge (MNWR). These include: greater sandhill crane, horned grebe, Franklin's gull, white-faced ibis, eared and western grebes, blackcrowned night herons, common and snowy egrets, Forster's terns, black terns, white pelican, bitterns, sora, Virginia rail, snowy plover, long-billed curlew, willet, American avocet, black-necked stilt, Wilson's phalarope, Caspian tern, scaup, mallard, gadwall, pintail, widgeon, shoveler, redhead, canvasback, golden-eye, ruddy ducks, green-winged, blue-winged, and cinnamon teal, whistling swan, Canada, white-fronted, and snow and Ross' geese (State Water Resources Board 1967:60-61; Hubbard 1975; McDowell 1992).

Mammals are also plentiful in the marshlands, meadows, and uplands surrounding the lakes, and include: muskrat (*Ondatra zibethica*), raccoon (*Procyon lotor*), mink (*Mustela vison*), long-tailed weasel (*Mustela frenata*), beaver (*Castor canadensis*), badger (*Taxidea taxus),* pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), Bighorn sheep (*Ovis canadensis)*, red fox (*Vulpes fulva*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), kangaroo rats (*Heteromyidae)*, mice and voles (*Cricetidae)*, jackrabbit (*Lepus californicus),* Cottontail (*Sylvilagus nuttalli)*, and pygmy (*Sylvilagus idahoensis)* rabbits.

Several fish taxa inhabit the lakes and streams of Harney Basin, and aboriginal exploitation of this resource is documented both ethnographically (Couture et al. 1986; Couture 1978; Whiting 1950) and archaeologically (Aikens and Greenspan 1988; Bonstead 2000; Ricks 2002). Modern fish species in Malheur Lake include bridgelip (*Catostomus colubianus*) and largescale suckers (*Catostomus macrocheilus*), redside shiner (*Richardsonius balteatus*), chiselmouth (*Acrocheilus alutaceus*), northern squawfish (*Ptychocheilus oregonensis*), longnose dace (*Rhinichthys cataractae*), speckled dace (*Rhinichthys osculus*), tui chub (*Gila bicolor*), redband trout

(*Oncorhynchus* sp.), rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsoni),* and mottled sculpin (*Cottus bairdi)* (Greenspan 1990:216).

Rattlesnakes, garter snakes, and lizards were also noted at the Weed Lake Ditch site. An abundance of Herps, including frogs and salamanders, is likely near the shoreline. In addition, numerous flies, most of them of the biting variety, were noted, as were red ants, scorpions, crickets, and many flying insects of unknown types.

Bison (*Bison bison)* apparently roamed the meadows around the lakes until relatively recent times. Trapper Peter Skene Ogden noted an abundance of bleached bones and weathered skulls throughout the region when he first passed through in 1826 (Brimlow 1951). During the 1930s, the drying of Malheur Lake exposed hundreds of skulls and two nearly complete skeletons of Bison. Vernon Bailey of the United States Biological Survey collected a sample of these specimens and described them as similar to *Bison bison bison*, but because of relatively longer and straighter horn cores and a slightly larger size, called them *Bison bison oregonus* (Bailey 1932; Brimlow 1951). Indigenous people utilized bison as recently as 320 ^{14}C yrs BP at the nearby Lost Dune site where Lyons (2001) found butchered bison bone within a dated hearth (Musil 2002:78). Grizzly Bear (*Ursus horribilis)* were also roaming the margins of the lake since its last highstand. Anan Raymond (1994) found a grizzly mandible lying on the surface of the Harney dune, along the northern margin of Harney Lake.

Hydrology. The Weed Lake Ditch site is located approximately one-half mile south of Harney Lake, which is the sump for the largest closed basin in Oregon – the Harney Basin. This drainage basin covers an area of roughly 5,300 square miles (Hubbard 1989). Harney Lake is most often a stand-alone lake receiving water inflow from Silver Creek via the Warm Springs Valley. However, when high precipitation levels and low evapotranspiration rates predominate over a series of years, the Malheur Lake, Mud Lake (a small lake found between the two larger lakes), and Harney Lake become one – Malheur-Harney Lake. Malheur Lake, located approximately 4.5 miles east of Harney Lake, is among the largest freshwater marshes in the United States (Hubbard 1975; McDowell 1992). The major contributors of moisture to Malheur Lake are the Donner und Blitzen River (~55%), the Silvies River (~28%), direct precipitation (~13%), and Sodhouse Spring (~4%) (Hubbard 1975). Before irrigation diversion of the Silvies River, it may have played a more important role than the Donner und Blitzen (Hubbard 1989). The Donner und Blitzen and Silvies rivers derive most of their water from snowmelt on the Steens Mountains and the Blue Mountains respectively (Wigand 1985, 1987; Dugas 1996). In low precipitation years, Harney, Mud, and Malheur lakes are sometimes dry, as in the droughts of 1889, 1924, and 1934 (State Water Resources Board 1967). In years with high snow pack, the lakes often spread over the lowlands to form one large lake.

The hydrologic records of the lakes from 1903 to present reflect dramatic cycles of seasonal, annual, and decadal water elevation changes. During the last thirty years several periods of particularly elevated precipitation rates and low evaporation rates resulted in all three lakes joining into one, exceeding the 4,092 feet (1,247 m) elevation required to do so (Hubbard 1975 and 1989). In 1984, the joined lakes reached an elevation of "4102.4 feet [1250.41 m] above sea level, the highest level in recorded history (1903-84), and covered an area of 170,000 acres (266 square miles)" (Hubbard 1989:1). The lake continued to rise, reaching a maximum elevation of 4102.6 feet

(1250.47 m) in 1986. Normal precipitation levels for the area surrounding Harney and Malheur Lakes is around 9 inches (22.86 cm) per year based on the average annual precipitation values between 1951-80. However, from 1978-84, this average was exceeded, and in 1984, the area received 13 inches (33.02 cm) of precipitation, resulting in massive flooding of surrounding farms and ranches and the record high lake level previously discussed (Hubbard 1989). Even at the 4102.6 ft (1250.47 m) highstand, the deepest part of Malheur Lake was only around 6 feet (1.83 m), and the lake surface remained rich in emergent plants. Since mid-to-late Holocene times, fluctuating lake levels have varied from completely dry to a flood level no higher than around the 1986 high of 4102.6 feet (1250.47 m) (Elston et al. 1992).

Malheur Lake and Harney Lake are of different bathymetry, which results in different vegetation and flood response signatures. While Malheur Lake is generally shallow and broad, Harney Lake is relatively deep and steep-sided. Malheur Lake spreads out over great areas when flooding occurs, while Harney Lake simply gets deeper until an elevation of 4100 feet (1249.68 m) is breached, upon which it begins to expand northwestward into the Warm Springs Valley (McDowell 1992). The broad, shallow Malheur Lake continues to support emergent vegetation even during flood levels, whereas Harney Lake is primarily open water with vegetation only around its margins at all levels. The elevation differences in the lake bottoms and input cycles result in Harney Lake, whose bottom elevation is the lowest in the basin at 4079.7 ft amsl (1243.5 m), becoming more saline over time, while Malheur remains relatively fresh due to the constant input of freshwater from the Silvies and Donner und Blitzen Rivers, which effectively flushes portions of its system (McDowell 1992).

The majority of precipitation received in the Harney Basin falls during the winter, with snowmelt resulting in peak discharge of the northern streams and Silvies River during the months of March, April, and May, and the Donner und Blitzen peaks approximately one month later (State Water Resources Board 1967; Wigand 1985; Dugas 1996).

Springs are also an important water source for inhabitants of the area and many are situated along the southern margin of the lakes (i.e. Sodhouse Spring, Double O Spring, unnamed springs). These springs have their largest output when lake levels are low and their hydraulic gradient greatest (Hubbard 1975; Waring 1909; McDowell 1992). Artesian wells also tap confined groundwater aquifers in Warm Springs Valley and south of Malheur Lake (Piper et al. 1939; Dugas 1996). Therefore, even when drought conditions are prevalent throughout the region, springs and aquifers provide potable water to the inhabitants of the area.

Although the Harney Basin is currently part of the hydrologic Great Basin, it was joined with the Columbia River system during the last highstand ca. 9,900 ^{14}C yrs BP (revised date reported herein). At an elevation of 4114 ft (1253.95 m), the sill of the Harney Basin (Malheur Gap) was breached – joining it to the Columbia system via the Malheur and Snake Rivers (Dugas 1996; Gehr 1980).

Geology. The Harney Basin is located within the High Lava Plains on the northern border of the geologic Basin-and-Range structural province that encompasses the majority of the Great Basin (Streck et al. 1999). The geologic history of Harney Basin is of importance to archaeologists studying early Holocene and Late Pleistocene peoples because of its control over geomorphic responses to changes in base level, the structural control of lake levels, the connection to the Columbia River system, and its creation of lithic resource concentrations (e.g. obsidian, basalt, rhyodacite) of interest to aboriginal peoples.

The existence of lakes during the early Holocene within the Harney Basin is due to a geologically recent flow of the Voltage Lava into Malheur Gap. The valley containing the flow may have formed as a headward cut of the South Fork of the Malheur River, which resulted in the loss of over 500 feet (150 m) of accumulated early Pleistocene sediment from the basin and into the Columbia system (McDowell 1992). Malheur Gap, the sill of Harney Basin, is presently at an elevation of 4114 feet (1253.95 m) (Gehr 1980; Piper et al. 1939). Creation of this sill by successive Voltage lava flows began during the Pleistocene, as evidenced by tephra deposits dated to between 70,000 and 80,000 years ago embedded in lacustrine sediments within the Malheur lakebed (Dugas 1996; Dugas 1998). The latest Voltage lava flows appear relatively "fresh", with little weathering that would indicate a great age (Gehr 1980; Dugas 1996; Nials 2002). However, these flows must have taken place by 9,900 ^{14}C yrs BP - the last highstand of pluvial Lake Malheur, which is at the same elevation as the sill at 4114 ft (1253.95 m).

The present landscape of Harney Basin is the result of Miocene age interstratified basalt flows, airfall, ashflow tuffs, tuffaceous sedimentary rocks, and subsequent faulting along the Brothers Fault zone. This fault zone, which runs through the southern portion of the basin and encompasses numerous normal faults trending northwest-southeast (Walker and Swanson 1967; Dugas 1996; McDowell 1992), has been active since the late Miocene. It has reportedly caused displacement of the Late Pleistocene and Holocene aged basalt at Diamond Craters (Brown, McLean, and Black

1980 *cited in* McDowell 1992:18). The recent activity along this fault zone may prove important in determining how beach ridges of an unknown age, but older than ca. 9,900 ^{14}C yrs BP, found south of both Harney and Malheur Lakes and at up to 4140 feet (1261.87 m) in elevation came to be, in some cases, up to 26 feet (7.92 m) above the sill of the basin (Nials 2002, personal communication; see also Dugas 1996; Elston and Dugas 1993:13; Elston and Dugas 1995:71; Nials 2002:17; Dugas 1992a:39).

Geomorphology. Given the dynamic environment of Harney basin during the Late Pleistocene and early Holocene, it is essential to reconstruct the geomorphic landscape of that time in order to understand how people were using the environment they lived in, and the climatic-dependent variables that formed it, such as fluctuating lake levels. For example, as Elston and Dugas (1993) point out, the depth of water determines the location of shorelines and marshes. Within deep lakes, marsh resources are limited to the periphery of the lake, whereas in shallow lakes, marsh resources are found throughout its many islands and embayments. Therefore, aboriginal inhabitants seeking marsh-related resources may have selected shallow lakes over deeper lakes (Elston and Dugas 1993; Young 2000).

Given the association of archaeological sites with shoreline features, it is important to locate past shorelines, date them, and try to correlate known segments to other areas. In this way, a predictive model of site distribution can be made based on recognizable temporal marker beds that can provide a stratigraphic framework for other, non-dateable shoreline sites. However, care must be taken when making these correlations, as Dugas (1992a) noted while drawing his geomorphic map of the Harney Basin.

> Correlation of particular lake levels is problematic for several reasons: 1) no detailed elevation control currently is available for most of them, 2) air-photo reconnaissance correlation with base map topography sometimes is limited, 3) tectonic distortion may have occurred in some areas, and 4) the elevation at which a particular feature formed at a given water level depended on its type. For example, spits and bars appear to be built higher than wave-cut terraces. Ridge-like features may have formed partially offshore as subaqueous bars slightly lower than correlated terraces; alternately, they may be storm deposited beach berms higher than the terraces [Dugas 1992a:39].

When shorelines do not contain complete stratigraphic sequences, places of aeolian deposition may give clues as to the environmental condition prevalent at the time, the sediment sources of the aeolian features (e.g. lake floors, beaches), and groundwater level (Dugas 1996). Just as dunes evidence periods of drought and erosion, high shorelines of imbricated gravels and bedrock wave-cuts indicate high effective precipitation in the region at the time of their creation. As Dugas (1996) explained, the implication of the sediment movement evidenced in the Harney Basin by large dune fields and deflation zones is that gaps in the stratigraphic record are likely to occur. For example, at sites 35HA1911, 35HA1028 (Elston et al.1992), and 35HA1914 (Elston and Dugas 1993), the stratigraphic sequence ranges in age from at least 70,000 to 80,000 years BP (represented by the T-64 tephra previously reported as 120,000 years old; Dugas 1998:276) to recent times within two meters depth, with significant temporal gaps reflected by eroded stratigraphic contacts (Dugas 1996:21).

Past geomorphological investigations produced numerous radiocarbon dates from stratigraphic sequences in varied environments of the Harney Basin (see Appendix A: table 5). Dugas (1996) obtained two radiocarbon dates on charcoal and a marsh-adapted gastropod species from a relatively coarse sand stratum of a dune island just north of the outlet from Malheur Lake to Mud Lake. This water-laid deposit of horizontally bedded sand with interbedded clay lenses and laminae lies at an elevation of 4087.9 ft (1246.0 m) and may have been deposited in a "fluctuating wave-worked lacustrine environment" (Dugas 1996:44). The dates of 9,290 ± 150 ^{14}C yrs BP (Beta-57833) and 9,500 ± 210 ^{14}C yrs BP (Beta-57834) were obtained from the gastropod shell and charcoal samples. These dates are close to the ca. 9,600 ^{14}C yrs BP date obtained by Gehr (1980) for a beach ridge of shingled gravels found at 4102.36 ft (1250.4 m) elevation. The dates are also close to those reported herein that indicate the water level was near 4114 feet (1253.95 m) in elevation at ca. 9,900 ^{14}C yrs BP, and that wet meadow existed at ca. 4107 feet (1251.81 m) around 9,540 ^{14}C yrs BP. Explanation for why temporally similar dates have resulted from nearshore deposits at different elevations follows.

Although radiocarbon dates from gastropod shell of this age lack precision, a general trend is readily apparent in the dates obtained. The dates indicate a rapid initial regression of the lake from the sill level (4114 ft; 1253.95 m) at ca. 9,900 ^{14}C yrs BP to an approximate level of around 4107 feet (1251.8 m) by ca. 9,540 ^{14}C yrs BP, as evidenced by the wet meadow/marsh deposit date from this elevation near the Weed Lake Ditch site. The pluvial lake continued to decline over the next several hundred years, dropping to ca. 4092 feet (1247.2 m) in surface elevation around the time that the sand and clay were deposited that Dugas (1996) dated to ca. 9,300 and 9,500 ^{14}C yrs BP at 4087.9 ft (1246 m). One of these dates was obtained from a marsh-related species of mollusc that showed no signs of postdepositional transport, indicating that the water level had to have been shallow enough for marsh development and therefore had a shoreline elevation of around 4092 feet (1247.2) by ca. 9,300 ^{14}C yrs BP. A subsequent rebound to around

4101.5 ft (1250 m) seems to have occurred over the next seven hundred years. A gastropod shell sample from a beach deposit found at 4098.92 ft (1249.5 m) along the southern shore of Malheur Lake dates to 8,440 ^{14}C yrs BP (Raven and Elston 1992). A date derived from the soil organics found at an elevation of 4110.3 ft (1252.82 m) by Dugas and Bullock (1994) is 8,070 ^{14}C yrs BP in age, meaning that the water had regressed to a point lower in the landscape for a sufficient amount of time for a soil to develop.

Dugas (1996) proposes that water levels after the initial decline of the lake remained relatively stable until ca. 7,300 ^{14}C yrs BP, as indicated by two dates of 7,760 $\pm$ 110 and 7,370 $\pm$ 200 ^{14}C yrs BP for shell-bearing shoreline deposits at approximately 4101.05 ft (1250 m) in elevation along the south shore of Malheur Lake.

Recent investigations at the Headquarters site by Heritage Resource Management (HRM) have revealed a high-energy littoral deposit at 4112.23 ft (1253.73 m) (Nials 2002) – near the same elevation (ca. 4114 ft; 1253.95 m) of the last shoreline dated to ca. 9,900 ^{14}C yrs BP during the Weed Lake Ditch Project. Nials (2002) suggests that one or more large storms deposited these well-sorted gravels that require vigorous wave activity to move their relatively coarse clasts onto the beach line. A similar energy requirement was needed to deposit the thick gravel spit bar that the Weed Lake Ditch site is situated upon, and the two subsequent gravel layers (the highest one of which is associated with the cultural stratum of the site) may also be the result of storm surges (Nials 2000; see also Gehr 1980:75).

If large storms are responsible for the gravel deposits found along the southern shore of pluvial Lake Malheur, it is likely that their deposition occurred during the winter months. The predominate wind direction in the region is from the southwest during the summers; however, large storms often come from the north during the winter, changing the predominate wind pattern and sending high-energy waves towards the south shore of the lakes (Nials 2001, personal communication; Gehr 1980). Elston and Dugas (1993) described a modern analog for this wave activity during the flood of 1984-86. "As the water level rose and fell, storm-driven waves and ice cut into shorelines, creating terraces and completely shearing the tops off numerous islands" (Elston and Dugas 1993:1). This destructive wave activity is rare in shallow water with emergent vegetation (e.g. Malheur Lake); however, Harney Lake, with its open water, steep-sided shores, and lack of vegetation, is more apt to have erosive, high-energy wave activity than its calmer neighbor (McDowell 1992:34).

Although no dateable remains were located in the littoral deposit excavated by HRM, radiocarbon assays from a marsh deposit located stratigraphically above the littoral zone, but below it in elevation at approximately 4103.5 ft (1250.75 m), produced ages of 7,200 $\pm$ 60 ^{14}C yrs BP (Beta-160183) and 6,920 $\pm$ 60 ^{14}C yrs BP (Beta-160184) (Musil 2002). These dates substantiate Dugas' (1996) supposition of a steady water level at approximately 4101.5 ft (1250 m) for several thousand years after the last highstand.

As lake levels dropped, first at ca. 9,900 ^{14}C yrs BP, and later after ca. 7,300 ^{14}C yrs BP, exposure of the lacustrine and beach sediments to erosive forces occurred along the receding shorelines. Aeolian transport whisked the sediment from the exposed surfaces as the groundwater table and the sediment cohesion made possible by it declined, effectively decreasing the weight of the sediment and making it more vulnerable to the erosive power of the wind. As sediment eroded from one place, it was deposited in another, usually on the downwind side of the lake or basin from which it came. A series of lunettes, dunes and dune islands formed as pluvial Lake Malheur regressed to current levels.

Therefore a study of both sides of the lake and both aeolian and lacustrine depositional environments could lead to a more complete understanding of the pluvial lake sequence and the potential human habitation of its shorelines. Dugas (1996) studied the Harney Dune, located on the northeast shore of Harney Lake, to do just this. According to Dugas' interpretation of the geomorphology of the dune, this stabilized sand dune has moved little since its creation during the maximum extent of the lake. The dune consists of a series of lacustrine and beach sediments near its bottom punctuated by soil formation events. The upper portion of the dune is aeolian dominated, as evidenced by cross-bedding and angled bedding planes (Dugas 1996). Unfortunately, although this sequence seems to correlate well with the southern shoreline records, no dateable material was located, making comparisons difficult.

During the 1970s, Keith Gehr obtained several gastropod shell dates for a sequence of gravel bars exposed in the Weed Lake drainage ditch cut between Harney Lake and Weed Lake, a shallow playa and associated flat south of Harney Lake. The dates range in age from ca. 32,000 ^{14}C yrs BP to 8,680 ^{14}C yrs BP (see Appendix A; Table 5 for a complete listing). The two youngest gravel bars described include a 9,620 ^{14}C yrs BP bar at 4102.36 ft (1250.4 m), and an 8,680 ^{14}C yrs BP shoreline gravel deposit reportedly from 4115.49 ft (1254.4 m). The snail shell sample retrieved for the 9,620 ^{14}C yrs BP assay was from a weathered (opaque), dense shell lens within the gravel bar exposed in the ditch. The 8,680 ^{14}C yrs BP snail sample came from an augered hole near the base of a wave-cut scarp at 5 to 15 cm below the surface (Gehr 1980). It is unclear whether these gastropod samples consisted of marsh or open lake adapted species. The radiocarbon assay submission form states that both samples were composed of predominately *Lymnea* (a marsh adapted snail), while Gehr's thesis states that they were predominately *Fontelicella hendersoni* (an open water adapted snail) (Gehr 1980:168). This discrepancy is probably of little to no consequence, however, if the snails were indeed marsh-loving species, it may indicate that marsh was found nearby rather than the open water proposed by Gehr (1980).

During the Weed Lake Ditch Project, both of Gehr's sample locations were re-examined and new specimens collected. A snail sample of *Fontelicella hendersoni* from the same dense but opaque and, hence, weathered, snail bed was retrieved from the 4102.36 ft (1250.40 m) gravel bar deposit with Gehr's help. The newly obtained radiocarbon assay on this shell sample dates to 9,550 $\pm$ 60 ^{14}C yrs BP (Beta-172011) – very close to the previously obtained 9,620 ^{14}C yrs BP date, especially when considering all of the problems noted for shell dates such as 'old' carbon uptake and diagenetic contamination and recrystallization (Benson et al. 1990). However, these white, opaque shells were extremely weathered throughout the exposure and it is possible that the diagenetic changes of the shell caused it to date slightly younger (ca. 9,600 ^{14}C yrs BP) than is indicated by its stratigraphic associations.

Located stratigraphically above this 4102.36 ft gravel bar is a wave-cut beach terrace at approximately 4117 ft (1254.86 m). At the base of the wave-cut ridge lies a gravel beach deposit created during the last highstand of pluvial Lake Malheur. Previous sampling of this gravel shoreline deposit by Gehr (1980) using an auger to retrieve gastropod shell from 5 to 15 cm below surface resulted in a radiocarbon assay of 8,680 ^{14}C yrs BP (Gehr 1980). During the Weed Lake Ditch Project, a backhoe trench was dug at the same location that Gehr sampled. With the advantage of the trench, it became evident that the shell located at 5 to 15 cm below surface consisted of bioturbated, reworked, and aeolian transported shell and sediment. However, the beach gravels were found ca. 55 cm deeper in the profile than Gehr's augured sample depth. Associated with these beach gravels, a dense gastropod deposit of nearly clear, and hence relatively unweathered shell, was found within the gravels at an elevation of approximately 4111.72 ft (1253.25 m). Although lower in elevation, this shell bed is still stratigraphically coeval with the high shoreline elevation of just under 4114 ft (1253.95 m). The newly obtained Accelerated Mass Spectrometry (AMS) date for this sample is 9,860 $\pm$ 80 ^{14}C yrs BP, which provides a revised date for the last highstand of pluvial Lake Malheur. The previously obtained shell date of 8,680 ^{14}C yrs BP could have been contaminated by diagenetic recrystallization (see Benson et al. 1990), or the shell may have derived from a nearby saltgrass meadow or marsh and accumulated through aeolian transport (see Geomorphic correlation in the Results section).

Bullock et al. (1994:25) and Dugas (1998) report a late Holocene, 1,040 $\pm$ 70 ^{14}C yrs BP highstand at 4113.77 ft (1253.88 m) on the southern shoreline of Lake Malheur within Trench C (parking lot) of the Headquarters site. Obtained from charcoal found beneath a wave-cut scarp and within beach sediments, this sample overlies a paleosol dated to 8,070 $\pm$ 80 ^{14}C yrs BP. No other investigations, including the Weed Lake Ditch Project, have found evidence of this ca. 1,000 ^{14}C yrs BP shoreline.

Recent evidence (Dugas 1996; Raven and Elston 1992; Dugas and Bullock 1994; Musil 2002; Wigand 1987) indicates that the climatic pattern of the Harney Basin began to change between 9,900 and 9,600 ^{14}C yrs BP. Less effective precipitation resulted in lower lake levels, averaging around 4101.05 ft (1250 m) in elevation until approximately 7,300 ^{14}C yrs BP. At that time, the lakes dropped to near modern levels, although they continue to occasionally rebound to a flood elevation of around 4102 ft (1250.29 m).

The Weed Lake Ditch Site

The Weed Lake Ditch site is located upon a large gravel-spit bar created during the last highstand of pluvial Lake Malheur. Lying south of Harney Lake within a protective embayment, this gravel bar extends eastward from a pronounced bedrock ridge that forms the southern margin of Harney Lake for nearly 1.5 miles (2.41 km) west of the site. The bar forms a partial barrier between Harney Lake and the southern, more ephemeral, Weed Lake and Weed Lake Flat. The Weed Lake Ditch Project has revealed that this small lake, found just over 1.5 miles (2.41 km) south of the site, contained marshland that extended north to the gravel spit bar that the Weed Lake Ditch site is situated upon shortly after the last highstand of pluvial Lake Malheur. Gastropod shell extracted from a marsh or wet meadow deposit, found at an elevation of 4107.6 ft (1252 m) and stratigraphically above the southern margin of the gravel spit bar, dates to 9,540 ± 60 ^{14}C yrs BP (Beta-172009).

Discussion

The data obtained in my study suggest that the last highstand of Pluvial Lake Malheur occurred around 9,900 ^{14}C yrs BP and was near the sill elevation of 4114 feet (1253.95 m) - probably overtopping it during this period. Although the lake began to recede shortly after this highstand, it apparently maintained sufficient water elevation to remain a single lake for several thousand years. These generally wet conditions prevailed until around 7,300 ^{14}C yrs BP in the Harney Basin. A drying trend is apparent after this date. Although fluctuations of water level have occurred throughout the Holocene, the water has never again reached the 4114 feet (1253.95 m) sill elevation – leaving these older beach bars intact.

An examination of data from other parts of the Great Basin reveals that the generally mesic climate of Harney Basin in the early-to-mid Holocene is not unusual. Examination of pollen samples from Hidden Cave in western Nevada reveals that pine and sagebrush predominate until ca. 10,000 ^{14}C yrs BP when pine pollen levels abruptly decline, indicating the retreat of the woodlands to higher elevations (Wigand and Mehringer 1985; Grayson 1993). However, the presence of cattail pollen until about 9,600 ^{14}C yrs BP indicates that marsh was able to persist in this drying environment for some time (Wigand and Rhode 2002:323). The lake in the Sevier sub-basin in Utah (Lake Gunnison) did not begin to recede until 10,000 ^{14}C yrs BP (Oviatt 1988; Benson et al. 1990:258). The last highstand of Pyramid Lake occurred around 9,500 ^{14}C yrs BP (Benson et al. 1990:258) and the persistence of low elevation Juniper there until 9,500 ^{14}C yrs BP is evidenced within a nearby packrat midden (Wigand and Nowak 1992:59). After this time, Juniper began retreating to higher elevations, and by ca. 8,000 ^{14}C yrs BP desert scrub dominated the pollen and macrofossil record (Wigand and Nowak 1992:59).

Wigand found abundant sedge pollen in samples from Alkali Lake Valley until around 9,500 ^{14}C yrs BP, after which it was replaced with saltbush-dominated shrub communities (Wigand and Rhode 2002:231). Nearby, McDowell found a shallow lake 7 meters lower than the Dietz sub-basin that dated to 9,800 ^{14}C yrs BP (1992:32). Fecal matter removed from the 9,400 ^{14}C yrs BP Spirit Cave burial site in the Carson sink of west-central Nevada reflects an environment dominated by saltbush scrub, but with evidence for the presence of marsh and aeolian environments, with small fish being the primary component (Wigand and Rhode 2002:324). In southern Nevada, Hackberry pollen is regionally abundant between 9,500 and 9,000 ^{14}C yrs BP and increased spring discharge and the subsequent development of black mats within the valleys of the Spring Range date to between 10,200 and 8,600 ^{14}C yrs BP (Quade et al. 1998 *in* Wigand and Rhode 2002:338). Evidence has also been found for fluctuating lakes within the Lake Mojave basin between 11,500 and ca. 8,500 ^{14}C yrs BP (Brown et al. 1990 *in* Wigand and Rhode 2002:338). The termination of the Pleistocene woodland occurred at 9,500 ^{14}C yrs BP in the Alabama Hills north of Owens Lake (Koehler and Anderson 1995 *in* Wigand and Rhode 2002:338).

A Great Salt Lake pollen core has a similar shrub to woodlands ratio at both 9,500 and 12,000 ^{14}C yrs BP. However, after 9,000 ^{14}C yrs BP, woodland pollen decreases and desert scrub increases (Spencer et al. 1984 *in* Wigand and Rhode 2002:348). In the northwestern Great Basin, Wigand et al. (1995) suggest a reorganization of the juniper woodlands and sagebrush steppe began around 9,500 ^{14}C yrs BP (Beck and Jones 1997). Faunal assemblages studied by Grayson (1979) and retrieved from the Connley Caves of southeastern Oregon suggests that the nearby Paulina Marsh was most productive between 7,000 and 9,500 ^{14}C yrs BP, with waterfowl and sage grouse reaching their greatest numbers at this time (Jenkins et al. 2000:6).

In summary, mesic conditions seem to have persisted within several portions of the Great Basin until between 7,000 and 8,000 ^{14}C yrs BP. Preliminary evidence indicates that the margins of the Great Basin remained somewhat wetter than those of the interior after the Younger Dryas (Madsen 1999). Wigand and Rhode suggest that the differential response to the drying climate and thermal maximum of the early Holocene reflects the regional influence of either the monsoonal systems in the southern Great Basin, the Pacific storm systems in the northern Great Basin, or the interaction thereof (Wigand and Rhode 2002:353). Monsoonal penetration into the southern Great Basin seems to have delayed the xeric conditions until later in the Holocene, whereas the strong Pacific storms allowed mesic conditions to continue in the northern Great Basin throughout the early Holocene (Wigand and Rhode 2002:354).

The persistence of lakes in the northern Great Basin, including the Harney Basin, can be explained by the incursion of strong Pacific Storms as outlined in Wigand's and Rhode's model (Wigand and Rhode 2002). However, more basins need to have environmental work undertaken for the period following the Younger Dryas before any patterns of mesic conditions can be deciphered. One of the problems facing climate reconstructions of this time period is the radiocarbon dating calibration problem. In addition, dates are being obtained from several different sources (e.g. ostracode, tufa, macrofossils, pollen, etc.), with varying potential for secondary contamination, and varying response times to climatic change (e.g. lake level changes vs. change in vegetation community). These problems, discussed in Benson et al. (1990), make correlation difficult.

CHAPTER 3: ETHNOGRAPHIC BACKGROUND

The Harney Valley Paiute, who live in a small colony near Burns, Oregon, are descendants of the once numerous Northern Paiute whose territory extended from the headwaters of the Silvies River and Silver Creek to the north, and to Catlow Valley in the south, but was centered on Malheur and Harney Lakes (Whiting 1950; Couture 1978; Couture et al. 1986). Only two ethnographies, done in the mid-to-late twentieth century, document the Harney Valley Paiute specifically: 1) a study of the use of sorcery in social control by Whiting (1950), and 2) an ethnobotanical study of the contemporary foraging practices of the Northern Paiute by Couture (1978). Additional published research on other groups of Northern Paiute in the Great Basin includes Kelly (1932), Wheat (1967), Fowler (1990), Fowler and Liljeblad (1986), Lowie (1924), Stewart (1941), and Fowler (1992).

The Harney Valley Paiute speak Northern Paiute, a subgroup of Western Numic, which is an offshoot of the Uto-Aztecan linguistic family (Fowler and Liljeblad 1986:435). The group is called the *Waada* Eaters by other Northern Paiute (Couture 1978; Whiting 1950; Kelly 1932; Fowler and Liljeblad 1986), in accordance with a common naming convention of the Paiute to identify those living in different territories by a prominent or staple food item (e.g. Groundhog Eaters, Cattail Eaters, etc.) (Whiting 1950; Fowler 1990). *Waada*, found in abundance along the shores of Malheur Lake, is a plant that produces a small black seed important to the Northern Paiute winter sustenance. In late summer, large numbers of people would gather to collect this seed and cache it for winter (Couture 1978; Whiting 1950).

At the time of European contact, Northern Paiute were numerous within the Harney Basin. Trapper Peter Skene Ogden in 1826 remarked that it was "incredible the number of Indians in this quarter. We cannot go 10 yards without finding them. No Indian nation [is] so numerous as these in all North America" (Ogden *cited in* Brimlow 1951:10). However, disease and the Bannock war resulted in the death or displacement of the majority of these Native Americans by the end of the nineteenth century (Couture 1978).

The *Waada* Eaters traditionally utilized diverse microhabitats throughout their territory. Plants provided a substantial portion of the traditional diet, and included roots, greens, berries, and seeds. In addition, plants also supplied important material for technology, including housing structures, basketry, clothing, fuel, cordage, and tools (Couture 1978:35; Couture et al. 1986; see also Fowler 1990). Hunting and fishing offered important nutrients as well, in addition to the animal skins and bone tools sometimes used in the manufacture of clothing and shelter. Importantly, these Northern Paiute did not specialize in the exploitation of one resource type, but utilized the entire range of resources available to them, from the salmon of the Malheur River, to the roots and game of the uplands, and small game, water fowl, insects, and marsh-associated plants such as *waada* and tule on the lake boundaries. This resource utilization followed a predictable pattern based on seasons of abundance and availability (Figure 5).

The marshes and wetlands of Malheur and Harney lakes provided reliable and often seasonally abundant resources to the early inhabitants of Harney Basin. However, like all marshlands, productivity would have been variable. As Fowler (1992) discusses, marsh richness is reliant on water level. If the water level is too high, emergent plants (e.g. hardstem bulrush, cattail) cannot thrive, and neither can the waterfowl that feed on them. If the water is too shallow, it will not support abundant cattails and tules (important nesting sites for diving ducks), or sago pondweed or duckweed (important

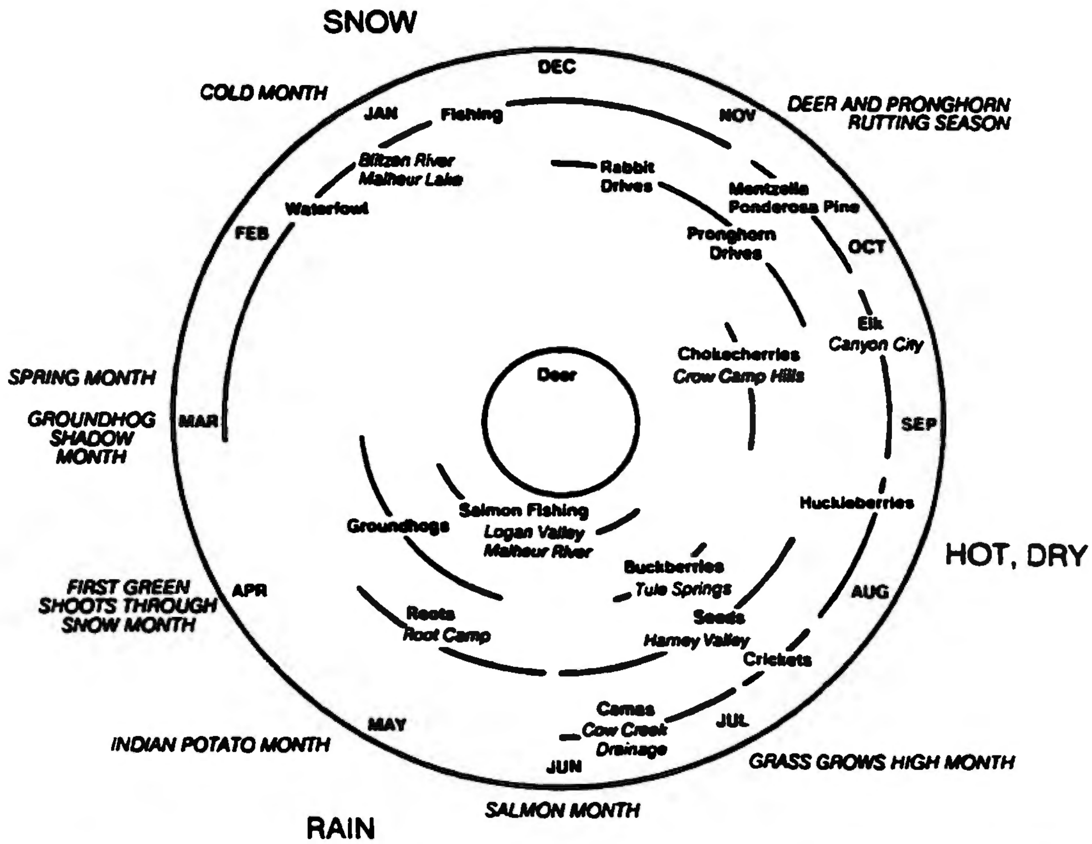


Figure 5. Seasonal Round of the Harney Valley Paiute (from Couture et al. 1986:153).

foods for waterfowl). Therefore, marshes must not be too deep or too shallow in order to be rich in both species numbers and diversity (Fowler 1992:44). In addition, different segments of the marsh system support different types of species, the location of which is relative to the proximity of the freshwater source or evaporation margin. As a result, within the same marsh, species abundance and type were dependent upon their relative position in the water cycle (Fowler 1992:46).

The shores of Malheur and Harney Lakes were important winter habitation sites for the Northern Paiute until recent times (Couture 1978; Whiting 1950). "Sites were selected which had a spring or some other source of water, a good supply of wood, and where it was known that there was not likely to be heavy snowfall. Most of the camps were at the foot of hills or in protected regions near the lakes. Here tule mat houses were set up" (Whiting 1950:19). The winter diet was limited to the cached supplies made during the previous year (e.g. Waada, crickets, chokecherries, dried meat, dried fish, etc.) supplemented by fishing, and fresh kills of rabbit, deer, antelope, and waterfowl over wintering near the lakes (Couture 1978; Whiting 1950). The Narrows between Malheur and Harney Lakes was recognized as an important winter fishing location (Couture 1978). The springs on the west side of Harney Lake, on the Double O Ranch, were also important overwintering sites. An October 10th journal entry in 1843 by emigrant Pierson Barton Reading commented on a Indian camp near the springs. "…After traveling a few hours, came into sight of two lakes lying about four miles distant from each other, one, the smaller, being fresh water which receives the Selvaille [Silvies] River; the other being much larger, I should judge about 20 miles in circumference, is salt water. At the west end of this lake we found a village of Indians which we passed through, and camped about 5 o'clock on a creek passing through a marsh" (Reading *cited in* Brimlow 1951:14). The creek mentioned may have been Silver Creek, which runs through the marshes of Warm Springs Valley.

Although the ethnographies do not mention the hot springs found between the Weed Lake Ditch site and the Narrows as an important location, Eagle's Nest, a prominent outcrop northwest of the hot springs, was noted as "important" by the Harney

Valley Paiute (Couture 1978:32). Hot springs are considered sacred by the Cattail Eaters, a Northern Paiute group located in central Nevada, and were often used for the healing properties of their hot water and mud (Fowler 1992:178).

CHAPTER 4:
ARCHAEOLOGICAL BACKGROUND

The Theoretical Development of Great Basin Archaeology

The archaeologists of the Great Basin were among the first to recognize the role of the environment in shaping culture. Julian Steward, in his Cultural Ecology model of Great Basin habitation, realized the importance of ecology in societal and technological development. In his *Basin Plateau Aboriginal Sociopolitical Groups* (1938), Steward states that societies are the result of their past and continued adaptation to the environment they live in. Steward was not an environmental determinist, but he did acknowledge that adaptation "necessarily involves an interaction of two elements: the natural environment and the particular cultural devices, invented and borrowed, by which the environment is exploited" (Steward 1938:2). Therefore, "ecological factors imposed certain conditions to which society had to conform and provided limits within which it could vary" (Steward 1938:236). This model generated awareness of the importance of past environments to anthropological concerns (Grayson and Cannon 1999:141). However, during this time anthropologists generally believed that aboriginal habitation of the Great Basin was limited to the past few thousand years (D. Fowler 1986; Grayson 1993). In addition, the people who did inhabit the Great Basin were thought to have originated from, or been heavily influenced by, the peoples of the southwest or California (Jennings and Norbeck 1955; Fowler 1986). The pristine basketry found within caves scattered about the Great Basin was taken as testimony of the recency of Great Basin occupation. Prevalent views of how the climate changed over time had it occurring at a slow and steady pace. Therefore, with only the few thousand years allowed for the habitation of the Great Basin, it was thought that the environment could not have changed enough in that period to effect the cultural development of its inhabitants. However, a few researchers such as L. Cressman and M.R. Harrington believed that cave sites that they were excavating contained artifacts of much greater antiquity than popularly allowed for the Great Basin cultures.

Cressman (1942) realized the importance of ecology in the understanding of people's past lifeways. To this end, and to prove the chronology of human habitation of the Great Basin, Cressman consulted with palynologists, vulcanologists, paleontologists, geomorphologists and paleoecologists in an attempt to recreate the environmental conditions that prevailed during the earliest habitation of southeastern Oregon. It was a vulcanologist, Howell Williams, who studied the ash layers found stratigraphically above sandal fragments in two of the caves Cressman was investigating and determined that at least one of the volcanic ash layers dated to between 4,000 and 10,000 years ago. Such an early date on a textile object was unheard of and many archaeologists remained skeptical.

Ernst Antevs was also a consultant to Cressman. Antevs became famous for his geochronological sequence for the Great Basin (Antevs 1955). Using the best climatic data available at the time, he postulated that the temperature and moisture regimes at different times in the Holocene were sufficiently distinct to divide the epoch into three stages—the Anathermal, Altithermal, and Medithermal. He described the earliest of these stages, the Anathermal (9,000 to 7,000 ^{14}C yrs BP), as cool and wet. The Altithermal was a period of warmer and more arid conditions between 7,000 to 4,500 ^{14}C yrs BP, and the most recent stage, the Medithermal (4,500 ^{14}C yrs BP to present), is more moderate than the Altithermal, but still warm and semi-arid (Antevs 1955; Minor et. al. 1979; O'Connell and Madsen 1982). Continued investigations have proven that Antevs' model is oversimplified (Madsen 1999), but it remains very influential. As absolute dating techniques became more widely used, specific local and regional chronologies were constructed. With these newly available interpretations, which are based on a diverse set of proxy data, a complex view of the dramatic temperature and precipitation fluctuations across the Great Basin is emerging (Madsen 1999; Madsen 2000; Grayson 1993; Wigand and Rhode 2002; Benson et al. 1990), making the generalized tripartite model that Antevs proposed seem obsolete.

Cressman and his interdisciplinary team finally proved the great age of the occupation in the Great Basin during the 1950s when a radiocarbon assay (one of the first performed) on a sagebrush sandal excavated from Fort Rock Cave dated to over 9,000 ^{14}C yrs BP. This discovery provided the "time depth that was needed for archaeologists to seriously consider effects of environmental changes on human populations in the Great Basin" (Rhode 1999:36; see also D. Fowler 1986:21; Grayson 1993). With the great antiquity of human habitation in the Great Basin proven, the cultures found here began to be studied independently of those of the southwest. In addition, archaeologists began to give more consideration to past ecological conditions, which were likely different when people first arrived in the Great Basin.

O'Connell and Madsen describe the 1950s as the beginning of the wide application of "descriptive ecology" in the Great Basin (O'Connell and Madsen 1982;

Rhode 1999; Beck 1999). Archaeologists and paleoecologists began undertaking comprehensive descriptions of the flora and fauna found in archaeological contexts and Jesse Jennings brought cultural ecology into the new era through his formulation of the Desert Culture concept (Rhode 1999; Beck 1999). Based on Steward's ethnographic research among the Shoshone, Jennings modeled the lifeways he saw represented in the artifacts of the well-stratified Danger Cave. He noted that the cultural attributes of the Shoshone, such as economy and social patterns, were heavily influenced by the severe and unpredictable nature of the environment of the Great Basin (Jennings and Norbeck 1955; Rhode 1999). Steward's ethnographic study of the Shoshone observed that these hunters and gatherers had a low population density, a kin-based band structure, and a simple technology. An annual seasonal round allowed them to exploit unevenly available plant and animal resources. Jennings and Norbeck (1955) hypothesized that the archaeological remains found in Danger Cave reflected this simple lifeway, which had not changed during the last 10,000 years (Jennings 1957; Jennings and Norbeck 1955; D. Fowler 1986:21). The Desert Culture, by Jennings and Norbeck's interpretation, was the most effective socioeconomic organization for coping with fluctuating environmental conditions. Therefore, even if past environmental conditions had been different than present, they would not have affected the adaptability of the hardy Desert Culture (Jennings and Norbeck 1955).

Other researchers (e.g., Heizer; Cressman) saw the Desert Culture concept as too simplified to explain the cultural variability found in the Great Basin. In addition, not all regions of the Great Basin were as fluctuating, harsh and unreliable as that occupied by the historic Shoshone. Oases exist within the Great Basin, including the marshes of the Humboldt and Carson Sinks and those along its northern and western margins. Jennings' and Norbeck's Desert Culture was not represented in these marsh-rich environments (Rhode 1999:37; Aikens 1970:202; Fowler 1977:25; Heizer 1966; Swanson 1964). Conversely, researchers working in the driest regions of the Great Basin began to use Antevs' Neothermal sequence to explain the lack of continuity in the archaeological record in those areas. If the cultural adaptations within the Great Basin had remained unchanged as in the Desert Culture model, why did the archaeological record exhibit distinct gaps? Antevs' tripartite model seemed to provide an explanation. During the Altithermal, portions of the Great Basin were too dry and hot for the survival of resources upon which humans relied, so people left the Great Basin.

However, Jennings' investigations at Danger Cave did not evidence any abandonment during the Altithermal. During the 1960s, Heizer and his students postulated that Antevs' "Neothermal sequence could explain large-scale patterns of occupation in the Desert West, in a manner as forcefully as Jennings (1964) expressed his distaste for that same idea" (Rhode 1999:39).

In the northwestern Great Basin, Bedwell (1973) proposed a new model—the Western Pluvial Lakes Tradition (WPLT), in order to explain the occurrence of early archaeological assemblages (including the characteristic Stemmed projectile point type) along pluvial lake shorelines. This model interpreted the occurrence of these sites as evidence for the specialization "in the exploitation of a lake, marsh, and grassland environment" (Bedwell 1973:180) and implied that north-to-south movement of peoples was common along lake margins. This model has been rejected by many archaeologists, predominately because of the occurrence of the same types of artifacts that Bedwell specifies as characteristic of the Western Pluvial Lakes Tradition in upland locations, the lack of permanent residences adjacent to marshlands, and evidence for increasing diet breadth (not decreasing) in response to the changing environment in the Early Holocene (Hoffman 1996; Grayson 1993).

The previous two decades of research had explored numerous aspects of site analysis and distribution in the larger context of environment, but O'Connell et al. (1982) proposed that although much data had been obtained, and that great gains had been made in cultural ecological modeling, more needed to be learned about the obvious interaction between culture and environment. In other words, researchers needed to get away from descriptive ecology in which the parallel development of culture and environment was noted, to search for explanation of the relationships. The methods of the "New Archaeology" promised to do just this (Rhode 1999:40).

The 1960s and 1970s saw the emergence of the "New Archaeology" throughout American Anthropology. Lewis Binford (1964) called for archaeology to become more scientific and anthropological (Johnson 1999). Binford stated that cultural-historical approaches did nothing to explain the *process* of cultural adaptation and change. He outlined the need to understand the function of artifacts within the larger context of society, not as just mere descriptions of style (Beck 1999:6). Binford's call was answered by many, and it was finally recognized that the Great Basin could not be understood as a large cultural complex that existed within a single environment, but that it must be seen as a large geographic area with many regional and localized variations-each which must be understood individually before an inter-regional model could be constructed (Rhode 1999). Researchers began to collect site-specific information in order to establish local archaeological and environmental chronologies. After accomplishing this, undertaking comparison of local chronologies with each other and regional trends allowed identification of specific environmental fluctuations within both local areas and over the Great Basin as a whole (Rhode 1999). Researchers such as David Thomas in his Monitor Valley, Reese Valley, and Alta Toquima projects applied processual methods to Great Basin problems. "Thomas applied sampling, statistics, a regional approach, conducted surface archaeology and simulation modeling, all within an overall ecological scheme" (Beck 1999:23).

One of the new models currently being applied in Great Basin studies is Behavioral Ecology. Although similar to the Cultural Ecology model proposed earlier by Steward, Behavioral Ecology incorporates evolutionary theory, particularly natural selection, and seeks to explain differences between cultures rather than just describe them (Kelly 1995). Under the auspices of Behavioral Ecology, an in-depth understanding of the environment in which people lived is necessary to effectively ask questions of the archaeological record. Optimal foraging models, including linear programming, patch-choice, and diet-breadth, require very specific knowledge of the location of potential resources, the seasons within which they were available and most abundant, and what the costs and benefits of acquiring these resources may have been (Kelly 1995; Rhode 1999). Behavioral Ecology necessarily focuses on foraging behavior because it is the most critical aspect of hunter-gatherer survival (Kelly 1995:63). The distribution and abundance of past resources affected the mobility, technology, and resource choices of the hunter-gatherers who lived in the Great Basin during prehistoric times. By understanding resource distribution and abundance, we achieve a better understanding of the decision-making system of these past peoples.

Summary. Near the turn of the nineteenth century, environment was seen as a steady backdrop in which slow cultural development and change occurred. With Antevs' tripartite climatic model came a growing awareness of recent climate change in the Great Basin; however, environmental change was still thought to occur slowly. In modern climatic models (see environmental background), it is clear that abrupt climate change(s) did occur within people's lifetimes, and would likely require cultural adaptation or technological innovation. "It is becoming increasingly evident that the transitions between the relatively steady state conditions, which characterize these millennial-scale events, are very abrupt, often on the order of a decade or less, and certainly within the lifetime of an individual. This means that fundamental climatic shifts take place in a step-wise fashion rather than in the sweeping curvilinear fashion of Antevs..." (Madsen 1999:75; see also Mehringer 1986:31).

Northern Great Basin Archaeology

Located on the hydrologic, physiographic, and cultural boundary between the Great Basin and the Columbia Plateau, the northern Great Basin is recognized as an area of transition between cultures, flora, and fauna (Butler 1965; Wigand 1987). Cressman, with his interdisciplinary team, was one of the first to explore the dry caves that allow the remarkable preservation of perishable artifacts and ecofacts in this region. However, the excellent preservation of perishable goods in caves has led to a bias in the archaeological record. Caves and rock shelters represent the majority of buried, stratified sites excavated in the Great Basin, with buried open sites rarely found or excavated (Beck and Jones 1997). Part of this bias is a fact of preservation and exposure. Buried open sites are hard to find in internally drained basins without a drainage cut or terrace to expose them if they are deeply buried. Therefore, most open sites found are those that have been eroded or deflated out of stratigraphic context-making them vulnerable to the elements and artifact collectors (Beck and Jones 1997). Due to exposure to weathering processes of both a chemical and physical nature, perishable artifacts are usually destroyed in both surface and buried open sites. As a result, Great Basin archaeology has a tendency to be interpreted based primarily on archaeological assemblages found in dry caves, skewing the data with the overrepresentation of these relatively rare caves in the analysis of landscape use (Beck and Jones 1997: 221).

The Weed Lake Ditch Site described herein will add to the data available for buried open sites. As with all open sites exposed to chemical and physical processes associated with rainfall, wind, and pedogenesis, the Weed Lake Ditch site has no perishable remains such as textiles or leather fragments, but yields only hardier bone and lithic materials. Because lithic material is most resistant to diagenetic processes, most open sites have only lithics and environmental context information available for the interpretation of site function. Of the lithic material, projectile points are considered the most temporally diagnostic of the many tools manufactured because their shape, flaking pattern, and hafting technology reflect both their function and stylistic differences between the groups of people who manufactured them. In the Great Basin, sites known to be early Holocene in age are most often associated with the Stemmed lithic tradition. Stemmed points consist of a variety of different types, all of which share grinding along the basal lateral margins, a product of the hafting technique used to mount them to a shaft. Stemmed projectile points found at the Weed Lake Ditch site are similar to the Haskett types defined by Butler in 1964.

Haskett. Defined by Butler (1964) from a site in the Snake River plain of southern Idaho in the mid-1960s, the Haskett point type is divided into two subgroups - Type I and Type II (Figure 6). Haskett Type I is characterized as broad and thick on its distal portion with a long, edge-ground basal section that tapers to a narrow, relatively thin and somewhat rounded proximal end. The basal section accounts for approximately 60 percent of the length of the point, which has a broad, shallow flaking pattern. However, not all of the specimens are edge-ground, nor do they all have such a distinct taper to the basal portion (Butler 1965:6). Butler describes Haskett Type II as similar to Type I, but as considerably longer and heavier with the blade and basal sections being of approximately equal length (Butler 1965:6).

Haskett points are currently thought to date between 7,240 and 11,200 ^{14}C yrs BP (Beck and Jones 1997: Table III), but dates more often cluster between 9,500 and 10,100 ^{14}C yrs BP (Sargeant 1973: 83-84).

Haskett points have been found from northwestern Wyoming to southeastern California (Sargeant 1973:101), but identification remains problematic (e.g. see Grayson

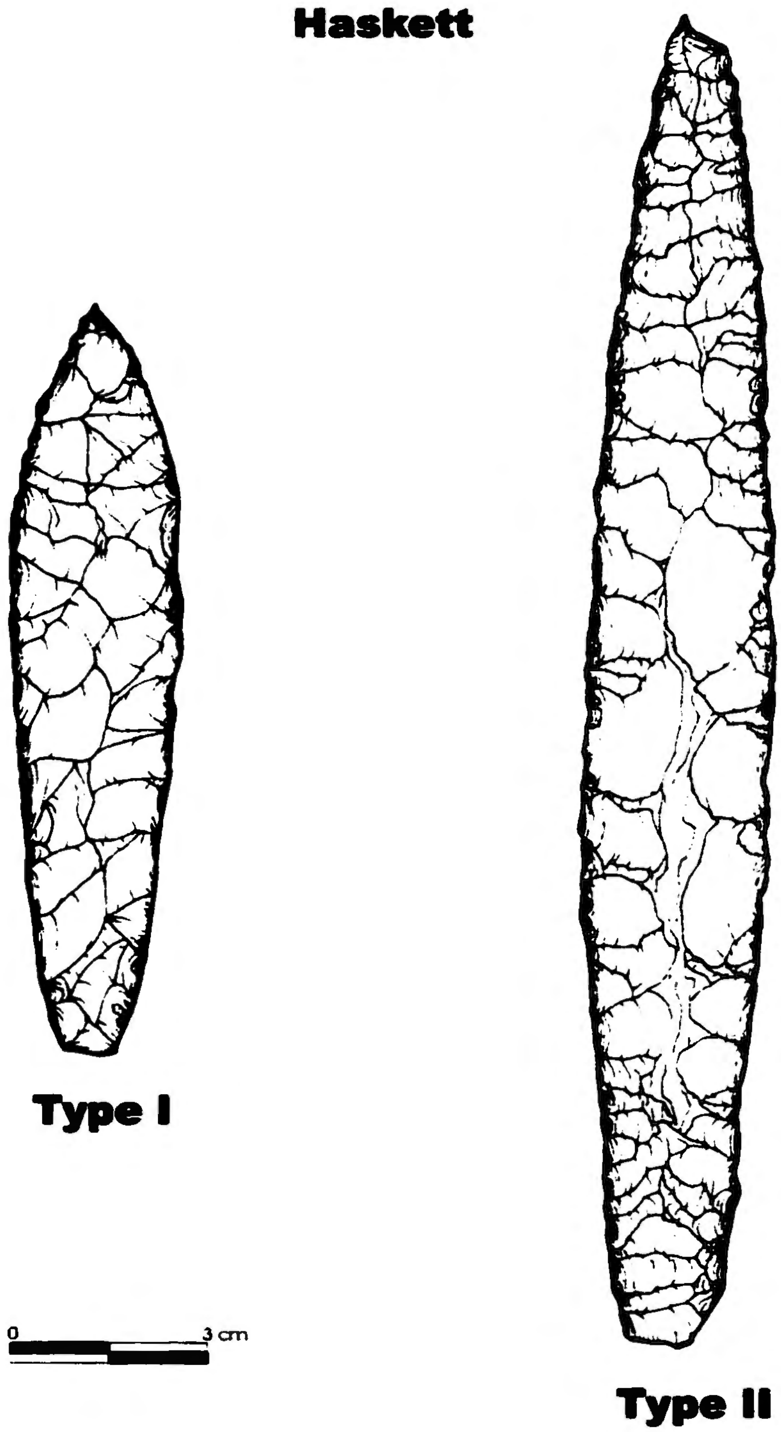


Figure 6. The two types of Haskett defined by Butler (1965; redrawn from Sargeant 1973, Figure 16).

1993: figure 9-3 as compared to Butler 1965: figure 9), as does the fact that descriptions of Haskett, Cougar Mountain and Lake Mojave points seem to overlap. Many investigators have subsumed the Haskett point type into more generalized point assemblages, such as the Great Basin Stemmed series, the San Diegito tradition, or the Hascomat complex (Sargeant 1973; Beck and Jones 1997). Therefore, identifying Haskett-bearing sites is problematic, for many Haskett points are simply identified as Stemmed projectile points.

According to Musil (1988:378-379), Haskett points may have been hafted on a socketed shaft. He separates the Stemmed Point Tradition into two sub-traditions based on hypothesized methods of hafting. The two hafting methods are 1) the parallel-sided technique, which continued the use of the split-shaft design found previously and includes point types such as Alberta, Scottsbluff/Eden points, and Windust points; and 2) a contracting-sided technique that hypothetically used a socketed shaft design for hafting. Projectile point types thought to use this technique include Agate Basin, Hell Gap, Lake Mojave, Cougar Mountain, and Haskett points.

> The advantages of a socketed contracting stem design over the fluted/lanceolate design are twofold: 1) the contracting of the stem removes the bindings from the blade edges, thus increasing the penetrating ability of the point; and 2) the long thick contracting stem is in contact with the wooden shaft over the entire stem length and the blunt thick base absorbs more of the force of the thrust. This is unlike the split-shaft design, which concentrates the impact on an already weakened split shaft with a wedge-like thinned point base. The socketed design suggests that better prevention of damage to the shaft is built into the design… [Musil 1988:379].

Several of the archaeological sites that date to the time period of the Weed Lake Ditch Site and/or are associated with the Haskett lithic tradition are discussed below in order to provide a regional context for interpretation of the Weed Lake Ditch site.

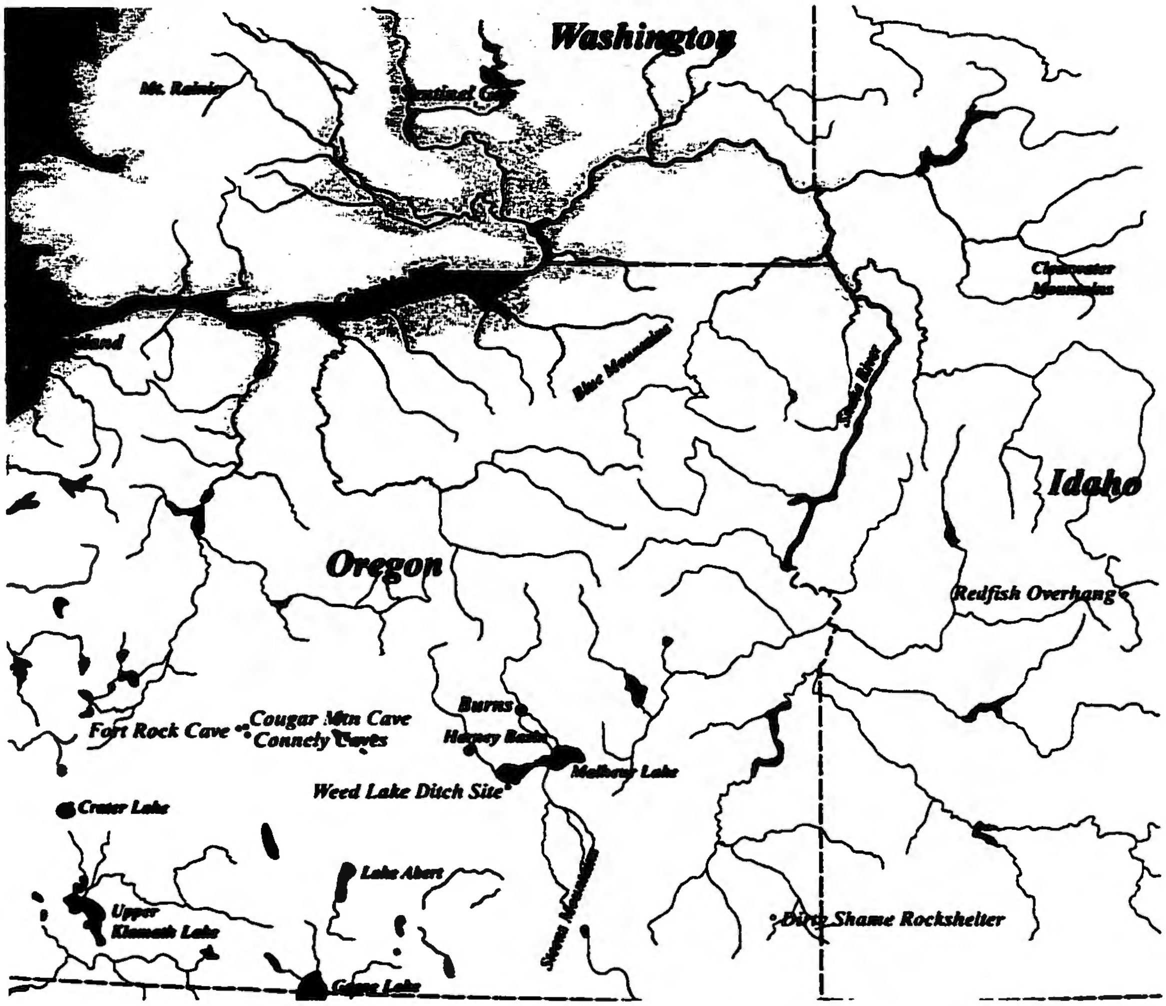


Figure 7. Northern Great Basin Early Holocene site location map.

Fort Rock Cave. Cressman first began his investigations at Fort Rock Cave, located in south-central Oregon (Figure 7), in 1938 (Cressman 1943). Although Fort Rock Cave is one of the most important sites in the Great Basin because it was the first dated to the early Holocene; its stratigraphy and artifact assemblage is generally poor. In the words of Cressman, the cave "failed to show convincing cultural stratigraphy. There were differences in the artifacts below and above the pumice, but since the whole stratum above the pumice had been reduced to white ash and all inflammable materials destroyed, we cannot say what had been there originally" (Cressman 1942:25). Bedwell (1970) continued excavations at the cave in the 1960s, increasing the numbers of artifacts recovered and better securing their stratigraphic associations. The early components of the site produced a large quantity of sagebrush sandals and a lithic assemblage that includes Stemmed, Foliate, Lanceolate, and Windust projectile points, bifaces, abraders, scrapers, gravers, choppers, a Crescent, a mortar, manos, awls, and drills (Jenkins et al. 2000:33). Based on the size and complexity of the assemblage, along with the fact that many of the sandals were muddy, it has been suggested that Fort Rock Cave may have been inhabited for a relatively long period, possibly over winter months (Jenkins et al. 2000:33).

Connley Caves. Connley Caves consists of six small rockshelter/caves above the northern margin of Paulina Marsh in south-central Oregon (Figure 7). Bedwell (1970) was the first to formally excavate there beginning in the 1960s and he identified three pre-Mazama (~ 6900 ^{14}C yrs BP) cultural units. Bedwell believed the first period dated to between 14,000 and 11,000 ^{14}C yrs BP, the second to 11,000 to 8,000 ^{14}C yrs BP, and the third to between 8,000 and 7,000 ^{14}C yrs BP. The unit dated to between 11,000 and 8,000 ^{14}C yrs BP had the richest cultural assemblage and included Windust, Foliate, and Stemmed projectile points, including Hasketts (Bedwell and Cressman 1971:18), various lithic tools such as bifaces, scrapers, gravers, choppers, and manos, and other, more perishable artifacts such as bone awls and textiles. The abundant faunal remains included "rabbits, sage grouse, waterfowl, and associated large herbivores (bison, elk, deer, antelope, and mountain sheep)" (Jenkins et al. 2000:33; see also Bedwell 1970; Bedwell and Cressman 1971). Given the prevalence of waterfowl in the faunal assemblage, and that waterfowl were available at the nearby marsh during the winter months, the Connley Caves may have been inhabited most intensively during the cold season, particularly during the 9,500 to 8,000 ^{14}C yrs BP period. Before (11,000 to 9,500 ^{14}C yrs BP) and after (8,000 to 7,000 ^{14}C yrs BP) that period, the Connley caves do not appear to have been used as intensely (Jenkins et al. 2000:33).

Cougar Mountain. In 1958, John Cowles, an amateur archaeologist, excavated Cougar Mountain Cave. Located approximately eleven miles east of Fort Rock Cave in south-central Oregon (Figure 7), this cave contained abundant archaeological material in its over 2 meters of fill that temporally spanned the entire Holocene. Cowles excavated to bedrock by 1-foot (30.48 cm) levels, screening all sediment through a one-quarter inch screen. Although the stratigraphic associations are questionable due to lack of documentation, Cowles notes the presence of an ash, incorrectly identified as Newberry Crater tephra, found at 2.5 feet (76.2 cm) below surface. This ash is more likely that from Mt. Mazama and provides a temporal marker of approximately 6,900 ^{14}C yrs BP. The assemblage from below this ash contained sagebrush and tule sandals, leather cordage, bone tools, and projectile points. Of interest to this study, the projectile point type found in the lowest portion of the cave, along with two-strand twist, braiding, and bison bone fragments, appears to be Haskett Type II (Figure 8), with a point type similar

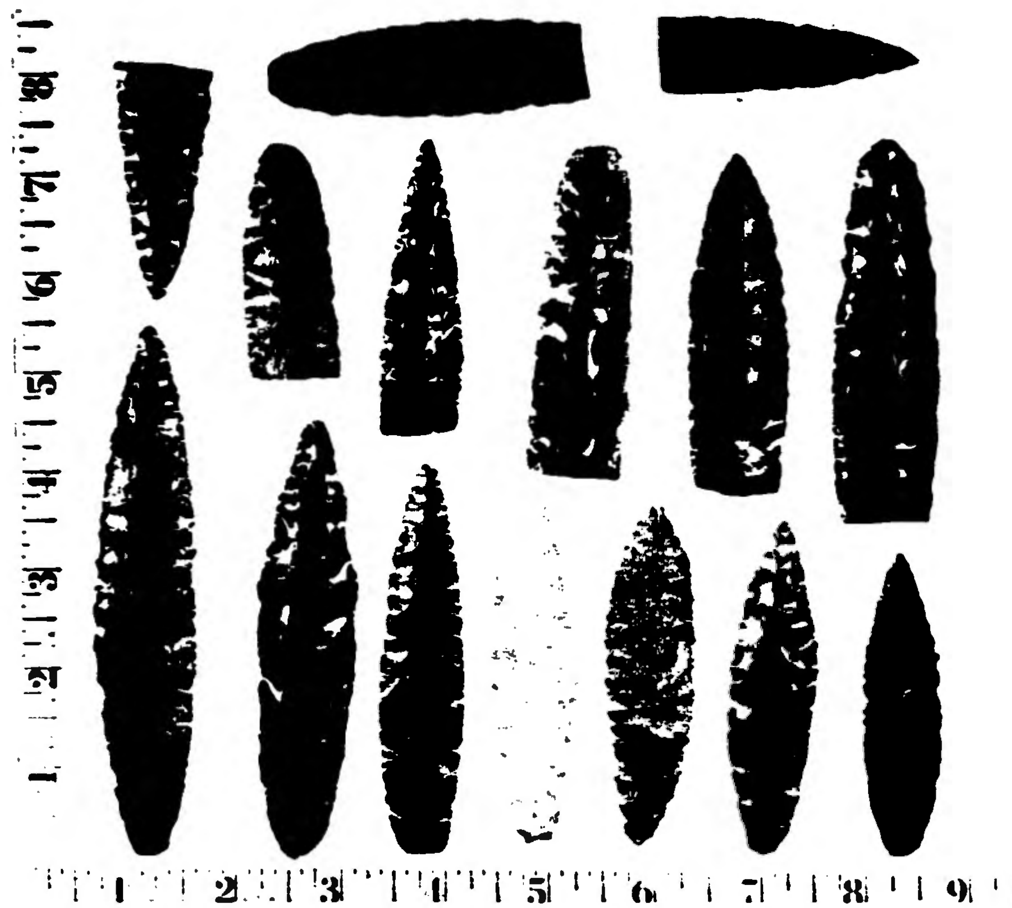


Figure 8. Possible Haskett Type II points recovered from the lowest layer of Cougar Mountain Cave (From Cowles 1959: Plate 1).

to Haskett Type I occurring directly above it according to Cowles description. This earliest cultural level was found on the gravels of the cave floor, which was "as clean as if it had been washed; there were no ash pits, no dirt, and no rubbish - just clean gravel" (Cowles 1959:35). I interpret this statement as evidence that Haskett projectile points, along with associated textiles and bone tools, were lying directly above and upon beach or water-laid gravels. The projectile points associated with this level (Figure 8; Cowles 1959: plate nos. 1, 2, and 6) appear to be Haskett, along with a point similar to the Haskett form identified as Cougar Mountain by Layton (1972).

Butler also recognized the similarities between the points found in the lowest level of Cougar Mountain Cave and the Haskett type (1965), as did Sargeant (1973). The Cougar Mountain Cave excavation also produced bone beads above the one and one-half foot level that are presumably associated with the Cougar Mountain points. However, these beads bear little resemblance to the bone bead preform found at the Weed Lake Ditch Site. Because of its relative complexity, and the presence of mud on the soles of the sandals, Jenkins et al. (2000:34) have suggested that Cougar Mountain Cave, like Connley Caves, may have served as a seasonal (winter?) residential base.

Dirty Shame Rockshelter. The Dirty Shame Rockshelter, excavated in 1973, is located in southeastern Oregon (Figure 7), just outside of the hydrographic Great Basin in the Owyhee river drainage. The earliest component exposed in the cave dates to 9,500 ^{14}C yrs BP. This date, obtained from charcoal, is associated with a point resembling specimens from some of the earliest layers of Cougar Mountain cave, and identified as a distinct point type named Cougar Mountain by Layton in 1972 and 1979 (Hanes 1988b:365). In addition, the cave contained two "Plano" type Stemmed projectile points, which may warrant further investigation as to any affinity with the Haskett point type.

Redfish Overhang. This site is found outside of the hydrographic Great Basin, within the Snake River plain of Idaho (Figure 7). Excavated by Sargeant (1973) in the early 1970s, the earliest component contained Haskett projectile points in association with two charcoal dates, 9,860 ^{14}C yrs BP, and 10,100 ^{14}C yrs BP (Sargeant 1973:62-63). Each of these dates is associated with separate Haskett point fragments, and the lowest and oldest date comes from atop gravels. Based on its high-altitude location and the large size of its lithic tools, Sargeant interprets the Redfish Overhang to be a big game hunting site. However, she notes the presence of a lake and marsh nearby that support residential and migratory waterfowl. The only faunal remains described from the site are those of ground squirrel (Sargeant 1973:70).

Sentinel Gap. Located in south-central Washington (Figure 7), this open, well-stratified Haskett occupation is dated to 10,200 ^{14}C yrs BP (Galm and Gough 2000; Galm et al. 2002). The artifact assemblage includes Haskett points, a dense lithic assemblage, two hearths, bone tools (including a foreshaft fragment), and bone beads and preforms similar to the one found at the Weed Lake Ditch site (Gough and Galm 2003; Figures 19 and 20). The faunal assemblage includes bones (and antlers) from bison, elk, deer, mountain sheep, rabbit, beaver, and badger, unidentified bird(s), and chinook salmon. Geochemical analysis of 17 flakes from the recovered sample of volcanic glass debitage provided source locations for 12 specimens; the remaining five specimens were too small for identification (Hughes 2000). Two of the flakes are manufactured from Obsidian Cliffs obsidian while another 10 flakes are assigned to Whitewater Ridge (Little Bear Creek chemical type) obsidian source. Obsidian Cliffs is located in the central Oregon Cascades and the Whitewater Ridge source is situated approximately 20 miles east of the town of Seneca in Grant County, Oregon (J. Galm 2003, personal communication). This source is less than 20 miles north of the floor of the Harney Basin. These flakes tentatively establish a relationship of the inhabitants of the Sentinel Gap site (or their trading partners) to the Harney Basin.

These short descriptions of well-stratified and/or dated sites in and around the northern Great Basin indicate possible cultural and/or technological affiliations of people that inhabited the Weed Lake Ditch site. Although it would be interesting to closely examine the Haskett technological complex and its cultural affiliations, it is beyond the realm of this thesis to do so. Therefore, I continue by outlining the early Holocene archaeological sites identified along the shorelines of Harney and Malheur Lakes.

Harney and Malheur Lakes

Intensive archaeological survey and testing did not begin in the area around Malheur and Harney lakes until the 1970s when Newman et al. (1974 *cited in* Aikens and Greenspan 1988) of Portland State University performed an archaeological surface survey of the area south of Harney and Malheur Lakes and recorded 166 sites. During one survey in 1976, a Humboldt point was found eroding from the Weed Lake drainage ditch. This find prompted investigations of the ditch by Keith Gehr beginning in 1977. Gehr (1980) recorded six new sites, including the Weed Lake Ditch site (35HA341) described herein. The early Holocene artifacts recovered by Gehr in his survey of the embayment surrounding the Weed Lake ditch include Stemmed and Concave Base projectile points and Crescents. Gehr (1980:113) characterizes the sites he recorded as lake margin occupations.

The flood of Malheur and Harney lakes during the mid-1980s exposed numerous artifacts along the recently scoured shoreline. These finds resulted in a surge of archaeological work in the area surrounding the lake (Chatters 1985), particularly on Malheur National Wildlife Refuge (MNWR) land.

In 1985, the United States Army Corps of Engineers (USACE) located nine early Holocene (based on the presence of Stemmed or Crescent artifacts) surface sites along the eastern shore of Malheur Lake. The other 121 sites located were of mid-to-late Holocene or historic age (Chatters and Rhode 1985 *cited in* Bonstead 2000). Heritage Resource Management conducted reconnaissance surveys surrounding Malheur Lake in 1988 and 1989 (Oetting 1990). These investigations resulted in the recordation of 14 burials and collection of 1,940 artifacts. Only 16 of these collected artifacts were Stemmed projectile points. All of the early Holocene collections were from the northwest side of Malheur Lake in an area likely covered by marshlands during that time (Bonstead 2000).

In the early 1990s, Raymond (1994) undertook surface survey of Harney Dune, located on the northeastern shoreline of Harney Lake. The base of the dune contained the highest artifact concentration, with artifacts found clustered in approximately five areas, the largest of which was located at Sand Gap - between Harney and Mud Lakes. Fire-cracked rock (FCR) clusters and stone net weights are included among the described features. Raymond collected seventy projectile points from the ground surface, including Desert Series (n = 14), Humboldt (n = 6), Rosegate series (n = 24), Elko series (n = 12), Northern Side Notched (n = 2), Cascade (n = 1), Crescent (n = 1), and Great Basin Stemmed (n = 3) projectile points. Although potential for buried deposits exists, no testing was performed.

In 1997, a Sundance crew led by Leif Christian (Clifford 1997) performed archaeological reconnaissance survey along old shorelines, concentrating their efforts to those between 4110 and 4125 feet (1252.73 to 1257.3 m) in elevation, and surveying intuitively selected areas extending from south of Harney Lake northwestward to Silver Lake. Twenty-seven sites were recorded, eleven of which contained Stemmed projectile point fragments and/or Crescents. Other point types noted include Gatecliff, Elko, and Concave Base. Occasional groundstone was also reported, but the sites are predominately lithic scatters located on the edges of alkali flats. Interestingly, most of the Stemmed projectile points were associated with gravel bars rather than other types of shoreline features.

Excavations at the Stubblefield Lookout site (35HA53) located south of Malheur Lake resulted in the recovery of projectile points ranging in age from early Holocene to protohistoric (Dugas et al. 1995:172). The compressed and confusing strata exposed Great Basin Stemmed and Northern Side-Notched points, but within questionable context (Dugas et al. 1995). Also located south of Malheur lake, the Headquarters site (35HA403), situated upon the Malheur National Wildlife Refuge (MNWR) Headquarters, was first recognized in the 1930s (Aikens and Greenspan 1988). As construction occurs at the MNWR Headquarters, so does archaeological work. Surface surveys have resulted in the recordation and/or collection of numerous projectile point types including Rosegate, Elko, Northern Side-Notched, and Great Basin Stemmed. Many lithic tools and groundstone have also been noted and several human burials have been recorded (Musil 2002:8-9). Backhoe excavations reported by Dugas and Bullock (1994) outline the complicated stratigraphy of the site. Occupation of the area around Trench C on the west side of the Refuge headquarters is believed to span from 300 to 8,100 ^{14}C yrs BP based on the presence of Rosegate projectile points in the upper strata and a lower component with a soil organics date of 8100 ^{14}C yrs BP. However, natural strata are mixed, so cultural associations are problematic.

In 2001, Heritage Resource Management continued test excavations east of the Refuge headquarters and found two cultural components. The upper component is similar to that found in earlier studies, with temporally diagnostic points from the last 6,500 years including Elko, Northern Side-Notched, Humboldt, and Rosegate types. The lower component contains a Stemmed projectile point resembling a Haskett (Musil 2002), two large bifaces, and a dense assemblage of lithic debitage lying within and on top of a mixed sand and beach gravel stratum presumably deposited during the last highstand of pluvial Lake Malheur at ca. 4111 feet (1253.03 m) in elevation. This lower component may represent a shoreline occupation coeval with that of the Weed Lake Ditch site. Stratigraphically above this lower cultural component is a marsh deposit dated to 6,920 and 7,200 ^{14}C yrs BP using soil organics (interpreted as ca. 8,000 cal BP by Musil 2002). Therefore, the lower component of this site is bounded by the last highstand of Pluvial Lake Malheur at ca. 9,900 ^{14}C yrs BP, and the younger marsh deposit dating to ca. 7,100 ^{14}C yrs BP.

The obsidian sourced from the lower cultural component originates far to the west of the site (Glass Buttes, a type also found at the Weed Lake Ditch site). This contrasts with the upper component obsidian that is derived from closer sources to the north and east (Musil 2002:83-84).

Site 35HA1911 was tested by Intermountain Research in the early 1990s (Botkin and Carambelas 1992a). This site is located on the southern shore of Malheur Lake, east of the Donner und Blitzen entrant and was recorded as covering approximately 57,200 m^2 by Oetting (1990). Its surface component included: Great Basin Stemmed, Northern Side-Notched, Elko, Rosegate, Desert Side-Notched and small side-notched projectile points, with Rosegate forms heavily dominating the collected assemblage (Botkin and Carambelas 1992a). Groundstone and three human burials were also located. A backhoe trench excavated in 1992 exposed a wave-cut at 4097.7 ft (1248.98 m) elevation. The recovered artifacts include three Rosegate specimens and a Great Basin Stemmed projectile point—all of which were found within 20 cm of the surface. The disturbed context of the tested location and shallow nature of the deposits hinders any interpretation thereof.

Site 35HA1028 was also tested by Intermountain Research in the early 1990s (Botkin and Carambelas 1992b) and is located on the southern shore of the Narrows – between Mud and Malheur Lakes. This site was first recorded by Nelda Hinton of Portland State University in 1973 (Newman et al. 1974 *cited in* Botkin and Carambelas 1992b) as a lithic scatter located on lacustrine sediments. Intermountain Research excavated a backhoe trench and test units here at an elevation of ca. 4102 feet (1250.29 m). Rosegate, Elko series, large side-notched, Humboldt, Desert side-notched, and one Great Basin Stemmed point were among the lithic tools collected. Rosegate and Elko points made up 76% of those collected. A single Stemmed projectile point was recovered from the surface. However, stratum 3, which contained a significant lithic assemblage, is dated from gastropod shell to between 7400 and 8400 ^{14}C yrs BP, so although no buried Stemmed points were found, the age of this stratum corresponds with that of other Stemmed sites (Botkin and Carambelas 1992b).

The Nials site (35HA2828) is found on the southern shoreline of Harney Lake, approximately 1.5 miles (2.41 km) east of the Weed Lake Ditch site. Discovered in 1997 (Clifford 1997), this site was tested by SARF crews in 1997, 1998, and 1999 (Bonstead 2000). The excavations revealed a single component assemblage from which five Stemmed projectile points, two Crescents, a worked bone object, 63 bifaces, over 26,000 pieces of lithic debitage, and 5,680 bone fragments (Bonstead 2000:1) were recovered.

Bonstead believes the cultural stratum dates to around 8,000 ^{14}C yrs BP (Bonstead 2000). The cultural stratum is bound by aeolian redeposited pumicite presumed to be Mazama ash (ca. 6,900 ^{14}C yrs BP) in the stratum above and by gravels deposited during the last highstand of Pluvial Lake Malheur (9,900 ^{14}C yrs BP) below.

Of the recovered faunal material, 480 pieces were identifiable. Fish (*Cypriniformes*) dominated the identified faunal assemblage, with 310, or 65% of the total; rabbits (*Leporidae*) made up 99, or 21%, of the identified bone fragments; while waterfowl remains made up only 3% (n = 14) of the specimens identified. No minimum number of individuals (MNI) was reported, so we have to be careful in relying too much on interpretation of these numbers, however, that said, people might have been relying on fishing and rabbit hunting for a significant portion of their diet at the time of this occupation.

A distinct distribution pattern of sites of differing ages is evident in the Harney Basin (Nials et al. 1998:6). Early Holocene point types, including Great Basin Stemmed, Concave Base, and Western Clovis, are usually found above 4120 ft (1255.78 m) in elevation (Nials 1999a; Nials 1999b). Although this is partly due to the fact that any occupations below ca. 4114 to 4117 ft (1253.95 to 1254.86 m) in elevation before ca. 9,900 ^{14}C yrs BP would have been reworked by wave action during the last highstand, the location of these sites along the shoreline and in apparent association with marsh strata, suggests that active shorelines and marsh environments were important resources for peoples (Nials 1999a). In contrast, late Holocene occupations are most often located near springs, suggesting a subsistence strategy different from that of the early Holocene (Nials 1999a; Bonstead 2000).

The Weed Lake Ditch Site (35HA341)

Keith Gehr, as part of his Master's thesis research, was the first to record the Weed Lake Ditch site (Gehr 1980:102-108), at that time named the Fenceline site. Gehr established the site boundaries as extending far to the west – up to the top of the gravel-spit bar and joining with the bedrock ridge above. In 1983, Bureau of Land Management archaeologists Marci Todd Enneberg and Ruth Bright again examined the site as part of a proposed road improvement project. At that time, they amended the site documentation, redrawing the site boundaries to encompass only the area of highest artifact concentration. The site name used on the Cultural Resource Inventory/Evaluation Record was South Harney Road, Site #2. The 35HA2827 site was recorded on the western portion of the gravel spit bar containing the Weed Lake Ditch site by a Sundance

Archaeological Research Fund (SARF) crew as part of a surface survey conducted in 1997 (Clifford 1997). The only diagnostic artifacts found within the site boundaries during this project consisted of Stemmed and Northern Side-Notched projectile points. Site 35HA2827 was originally contained within the boundaries of the Weed Lake Ditch site as drawn by Gehr in 1977 and several of the diagnostic artifacts Gehr collected during his recordation of 35HA341 were found within the present boundaries of site 35HA2827.

Other sites in the area that are pertinent to this investigation include the Ditch Site (35HA342) and Biting Fly Site (35HA1260).

Keith Gehr also recorded the Ditch Site (35HA342) (Gehr 1980:86-102). The site boundaries were drawn to encompass the entire Weed Lake drainage ditch, which extends nearly a mile from Weed Lake on the south to Harney Lake on the north. Unfortunately, the site boundaries for the Weed Lake Ditch site (35HA341) and the Ditch site (35HA342) actually intersect at the juncture of the gravel-spit bar and the Weed Lake drainage ditch. The Ditch Site (35HA342) is multi-component, exhibiting a diversity of artifacts in varying depositional contexts that range in age from the early Holocene to Late Prehistoric. The artifacts of 35HA342 that were extracted from the ditch cut and within the site boundaries of 35HA341 consisted of an *in situ*, complete stemmed projectile point and a flake; both projectile point typology and their stratigraphic position suggest that these artifacts represent part of an early Holocene occupation. And, given the proximity of these artifacts to the Weed Lake Ditch site, it is recommended that they be considered part of the 35HA341 assemblage.

SARF investigators first recorded the Biting Fly site (35HA1260) in 1997 (Clifford 1997), and subsequent surface collections were made in 1998, 1999, and 2000 (Branigan 2000). Limited test excavations were performed during the 1997 and 2000 seasons in order to determine if intact cultural remains were still present at this exposed site. This resulted in the recovery of one diagnostic artifact – a Crescent – from subsurface context (38 cmbd) along with numerous pieces of lithic debitage (Branigan 2000). The cultural layer consisted of a thin zone immediately above and within a saltgrass meadow deposit. Shallowly buried, the occupation zone is largely exposed, with little potential for the future recovery of intact buried cultural material. The surface of the Biting Fly site contains artifacts ranging in age from the early Holocene to Late Prehistoric period with the majority being early Holocene age Stemmed projectile points and Crescents. This site is associated with the eastern portion of the beach bar that contains the Weed Lake Ditch site. However, the early cultural component of the site is found stratigraphically above that of the primary cultural stratum of the Weed Lake Ditch site (Figure 13). Therefore, the Biting Fly cultural zone is younger than that of the Weed Lake Ditch site, and may be coeval with the habitation of the nearby Nials site (Bonstead 2000) at around 8,000 ^{14}C yrs BP.

Summary of Malheur-Harney Lake Archaeology. After looking at the archaeological material recovered from the shorelines of Malheur and Harney Lakes, it becomes evident that the Weed Lake Ditch site is unique in that it provides good stratigraphic control, organic material for radiocarbon dates, and a distinct projectile point type known as Haskett. The best correlation thus far is found at the Headquarters site, south of Malheur Lake, where a possible Haskett point was found in association with the last highstand deposits (Musil 2002). However, only a bracketed date is available for that component of the site.

The majority of the archaeological remains recovered from the shorelines of Malheur and Harney Lakes date to mid-to-late Holocene (see Appendix A; Table 5). However, these results could easily be a product of where the research has been carried out. Many of the excavations so far reported are below the ca. 4114 foot (1253.95 m) elevation of the last highstand of Pluvial Lake Malheur. If we are to find early Holocene and older buried sites, excavations need to be undertaken above this elevation (Nials 2002).

CHAPTER 5: METHODS

The Weed Lake Ditch Project was completed in three phases during the summers of 2000, 2001, and 2002, and included test excavations, surface survey, backhoe trenching and augering. The initial phase in 2000 was the excavation of two one-meter square units adjacent to the drainage cut and centered on the exposed *in situ* Haskett Stemmed projectile point, flakes, and bone. The second phase in 2001 entailed a pedestrian survey of the land controlled by the Bureau of Land Management (BLM) within the fossil embayment that contains the site, the excavation of six additional one-meter units adjacent to the previous excavation pits, and the excavation of four backhoe trenches near the mouth of the embayment containing the site. The final phase in 2002 included the excavation of four more backhoe trenches and three auger holes adjacent to the gravel-spit bar upon which the site is located.

Field Methods

The investigation used standard archaeological field methods including detailed profile mapping and description, controlled stratigraphic excavation, wet and dry screening, artifact and sample collection, reconnaissance survey, backhoe trench excavation, augering, and topographic mapping. Nikon and Leica total stations were used to map the surface elevations of all of the backhoe trenches, auger holes, and excavation units relative to a USGS benchmark (118 MDC 1973) located on the Malheur National Wildlife Refuge. All relevant artifacts, samples, and features were mapped using a Global Positioning System (GPS) unit to establish their Universal Transverse

Mercator (UTM) coordinates. For analysis, these data were downloaded into the Arcview 3.2 Geographic Information System (GIS) program.

Profile Mapping and Description. After the initial find in 2000 of an *in situ* lanceolate projectile point fragment within the wall of the ditch cut, further investigation revealed two bone fragments and 12 pieces of lithic debitage exposed nearby. The artifacts were mapped and temporary provenience controls established. The wall was then cleared of vegetation and straightened to vertical. Fred Nials drew a detailed stratigraphic profile of the ditch wall (Figure 12). This profile was used to guide excavators in stratum identification and analysis during subsequent work. The profile includes detailed descriptions of each stratum outlining its texture, bedding, color, structure, degree of sorting, and grain size (see Appendix B and Nials 2000). After the excavation was completed, the wall profile was re-mapped using the same procedures outlined above.

Excavation of Test Units. Approximately four square meters of ditch-excavation spoil dirt were removed from the top of the units before the initial phase of archaeological excavation began. Centered on the exposed artifact concentration, two one-square meter units were established. A rebar datum was placed outside of the excavation area.

Excavation was by ten-centimeter arbitrary levels, which, if necessary, were further subdivided by stratum. Each stratum and/or level was screened separately using a 1/8-inch dry screen. Sediment samples were taken from each individual stratum for future analysis. Every stratum was mapped and numbered and a sediment sample of each was analyzed for texture, color, and consistency (Foss et al. 1975; Munsell soil color charts).

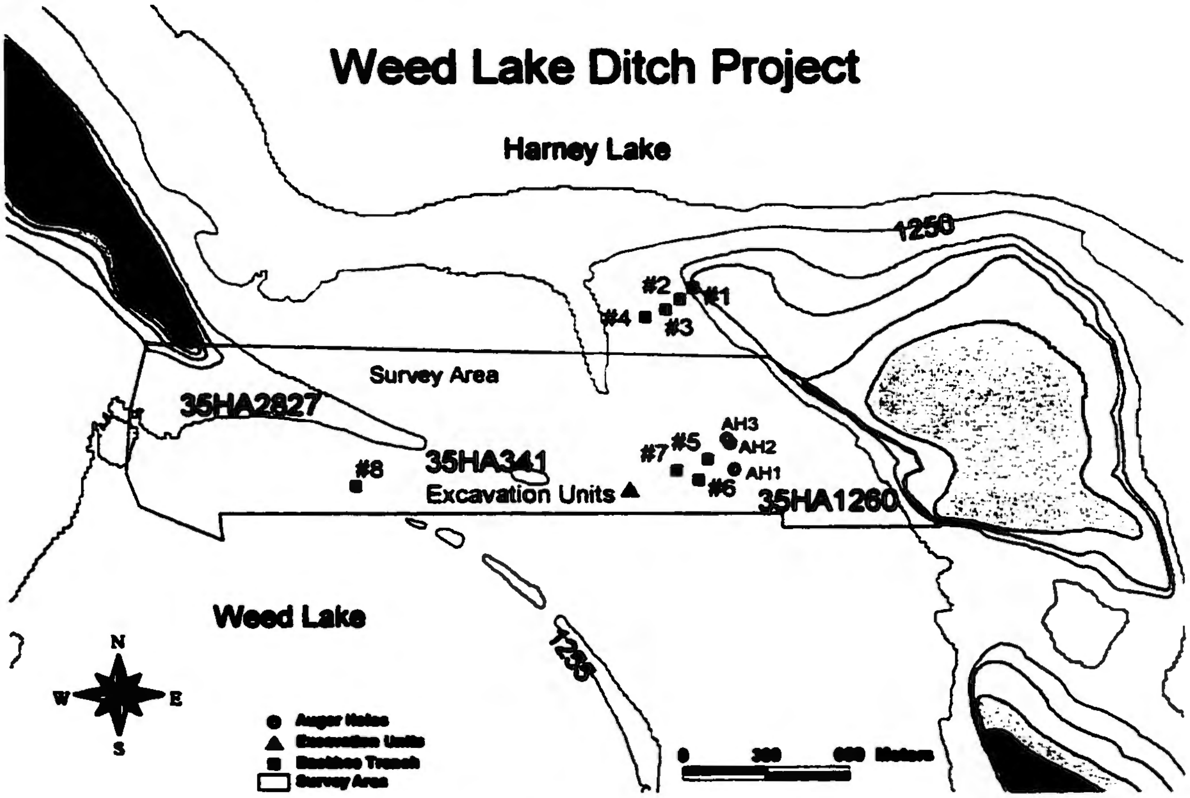


Figure 9. Weed Lake Ditch Project Area showing survey area, backhoe trench, excavation, and auger hole locations.

During the 2000 field season, units A and B were excavated to 130 cm below datum, past the visible artifact concentrations and into the gravel horizon underlying the primary cultural stratum. The test units, ditch wall, and elevation of each identifiable stratum were mapped using a Leica total station

In 2001, and 2002 six more one-meter square units were excavated to the north, south, and east of the previous year's units (Figure 11). Two excavation datum points were created and correlated with the previously established datum.

The excavation procedures established in 2000 were again followed with three exceptions. Units C, D, E, and F were broken down into 5 cm (instead of 10 cm) arbitrary levels upon reaching the cultural stratum. Units D and F were wet screened using 1/16-inch mesh screen, and the bottom of the units was determined individually. Excavation terminated upon reaching culturally sterile sediment or as time allowed (Unit C – 130 cmbd, Unit D – 130 cmbd, Unit E – 110 cmbd, Unit F – 110 cmbd, Unit N – 130 cmbd, Unit O – 130 cmbd).

Pedestrian Surface Survey. The intent of the surface survey was to provide an accurate sample and topographic distribution of the exposed artifacts within the embayment containing the Weed Lake Ditch site (Figure 24). Four hundred and fourteen acres were surveyed. A slow pace was encouraged and 15-meter intervals maintained. All lithic tools were either drawn and described or collected, and UTM locations, descriptions, material types, stage of manufacture, and environmental settings were also noted.

Backhoe Trench Excavation. In 2001, Fred Nials directed the excavation of four backhoe trenches within the northeastern portion of the embayment containing the site. Trench #1 was excavated at the location from which Gehr (1980: 75) obtained the shell dating to 8,680 ^{14}C yrs BP, at the base of a steep wave-cut ridge. The other three trenches were excavated down slope from the first and in a line perpendicular to the slope so that a cross section of the lake sequence deposits could be viewed (Figure 13).

In 2002, four additional backhoe trenches were excavated. Three of these were placed between the Biting Fly and Weed Lake Ditch sites, just north of the gravel-spit bar upon which the Weed Lake Ditch site is situated; the fourth was placed south of the gravel-spit bar and to the west of the Weed Lake Ditch site. The first three locations were chosen in order to link stratigraphic profiles of the Biting Fly and Weed Lake Ditch sites and expose the 8,680 ^{14}C years BP and 9,620 ^{14}C years BP gravel bars previously documented by Gehr (1980). The purpose of the fourth trench was to find dateable marsh deposits that potentially could be linked temporally and stratigraphically to the cultural stratum at the Weed Lake Ditch site. The most suitable place to have excavated such a backhoe trench was on private land, so a less suitable location was settled upon south of the gravel-spit bar and north of the fence line boundary at the site.

The backhoe profiles were mapped and photographed and the texture, color, bedding, structure, degree of sorting, and grain size of each stratum noted.

Auger Hole Excavation. The three auger holes were placed between the Biting Fly site and the three easternmost backhoe trenches in order to better establish the stratigraphic connection of the Biting Fly and Weed Lake Ditch sites. Using a hand auger with a sand bucket, excavations were by ten-centimeter levels with each bucket of sediment laid out in sequential order for examination. The samples were described as to their texture, color, coatings, and degree of effervescence when exposed to hydrochloric acid.

Sample Collection. Numerous sediment, ostracode and gastropod samples were taken from the ditch wall during the site investigations. Several of these samples were taken with the help of Keith Gehr at locations from which he had previously obtained samples and radiocarbon dates so that his findings could be replicated.

Lab Methods

Standard laboratory methods were used in the analyses of the site collections, including: lithic analysis, faunal analysis, radiocarbon dating, and XRF analysis.

Lithic Analysis. Each lithic tool was identified based on its shape, bifacial/unifacial flaking patterns, degree and type of use-wear, and stage of manufacture according to guidelines presented in Andrefsky (1998). All lithic tools were either illustrated, photographed, and/or scanned, although only the projectile points are included herein. The remainder are available at the Sundance Archaeological Research Fund (SARF) library at the University of Nevada, Reno.

Projectile Points. All projectile points were measured for maximum length, thickness, and widths. Points were identified to type based on visual and metric comparison with established Great Basin point typologies including Ireland (1983), Butler (1965), and Sargeant (1973).

Table 1. Biface Reduction Stages (modified from Andrefsky 1998)

Biface Stage	Description
I	Cobble with approximately 90% cortex remaining. A few flakes removed.
II	Margin has been flaked bifacially with approximately 80-20% cortex remaining.
III	The majority of the cortex has been removed, leaving less than 20%. The biface has been thinned.
IV	The thinned biface is relatively flat in cross-section and has little, if any, cortex remaining. The margins have been finely flaked.
V	The finished biface has edge retouch, with possible evidence of hafting.

Bifaces and Other Lithic Tools. Bifaces were classified after Andrefsky (1998) into a five-stage reduction continuum. In addition, material types, shapes, and maximum dimensions were noted. The relative percentage of cortex present, the thinness of the biface, and amount of edge retouch determined the stage of bifacial reduction (Table 1).

Unifacially worked tools and retouched flakes were described individually, noting material type, shape, maximum dimensions, and retouched and/or utilized margins.

Debitage. Flakes were analyzed individually by stratum and/or level and assigned to one of the following categories: decortication (dorsal surface > 50% cortex), secondary (dorsal surface <50% cortex), bifacial thinning (no cortex, bulb of percussion present), core reduction (cortex on platform), pressure flakes (less than 50 mm in maximum length, no cortex), shatter (angular fragment with no bulb), or unknown (fragment with no bulb or cortex). Additionally, the material type of each piece of debitage was noted. Due to time constraints, the debitage recovered from the screen of units C, E, and N were only counted. Lithic debitage were analyzed for five (units A, B, D, F, and O) of the eight excavated units to establish the relative amounts of each type of debitage in the assemblage.

Faunal Analysis

The maximum dimensions of the single bone bead preform recovered from the site have been noted. The artifact has also been described, scanned, photographed, and examined by zooarchaeologist Dr. Stephanie Livingston. Visual and metric comparison with bone beads from other early Holocene sites has been made from scaled photographs.

Dr. Livingston inspected all of the salvaged bone and made identifications of element, family, genus, and species whenever possible (Livingston 2003). This task was difficult because of the fragmented nature of the bone, and relatively small size of the material. Identification of intrusive bone was accomplished primarily by color. All of the non-intrusive bone from the primary cultural stratum (4) is uniformly dark brownish-gray, probably as a result of permineralization. However, intrusive bones were easily identified because of their light tan color and, in some samples, the presence of sinew; although identified to species whenever possible, intrusive bones were not included in the final analysis. Summary results of Dr. Livingston's faunal identification are presented in the following chapter. The full report (Livingston 2003) is available at the Sundance Archaeological Research Fund library at University of Nevada, Reno.

In 2000, a bone sample was submitted to Beta Analytic for accelerator mass spectrometry (AMS) dating; however, it proved to be too degraded to provide dateable material and no subsequent samples have been submitted.

Gastropod shell from the excavations has been catalogued, counted, weighed, and, when possible, identified to genus and species. Shell samples were also collected from various strata of the drainage cut and backhoe trenches for dating and identification purposes. Complete shells were identified by visual comparison with those described and illustrated in Gehr (1980). Environmental preferences of identified taxa are also extrapolated from Gehr (1980).

All of the four radiocarbon dates obtained during the project are from gastropod shell. Although shell dating is sometimes problematic because of uptake of old carbon during the snail's lifetime or diagenetic changes and recrystallization of the aragonite in the shell, these problems can be minimized by taking multiple samples and selecting only clear, and hence relatively unweathered, shell for dating (Nials 2001, personal communication; see also Benson et al. 1990:245). The dated gastropod samples were sorted by both species and transparency with only relatively unweathered and complete shell submitted for AMS dating (see below) whenever possible.

Sediment Analysis

Sediment texture for each stratum was determined in the field using criteria established by Foss et al. (1975), and sediment color was derived by comparison with a Munsell soil color chart in soft light. Sediment samples were collected from each level and stratum for future analysis.

Chronology

Two radiocarbon samples, one of charcoal, and one of bone, were submitted to Beta Analytic of Florida in October of 2000 for Accelerator Mass Spectometry (AMS) ^{14}C dating. Both samples proved to be too degraded to obtain a reliable age. Another charcoal sample was submitted for AMS ^{14}C dating in September of 2001 and one gastropod shell sample was submitted for the same in October of 2001. Three additional gastropod shell samples were submitted for dating in October of 2002. AMS dates were obtained from five of the samples submitted, one on charcoal, and four on shell. The charcoal date is modern in age and is not considered an accurate radiocarbon date for the cultural stratum. See the results section for a discussion of the findings.

XRF Analysis

A total of twenty-seven obsidian and rhyodacite artifacts were submitted to Northwest Research Obsidian Studies Laboratory of Corvallis, Oregon for X-ray fluorescence (XRF) analysis, or obsidian sourcing. All but four of the artifacts were selected from those retrieved from excavation of the primary cultural stratum (4) on site.

Of these four, one is a large Stemmed projectile point found within the ditch side wall by Keith Gehr (1980) in the late 1970s, one is an obsidian retouched flake from backhoe trench #1, and two are randomly selected projectile point fragments found during the reconnaissance survey. The results are discussed in the following section.

CHAPTER 6: RESULTS

The archaeological excavation, surface survey, and backhoe trench excavations at the Weed Lake Ditch site resulted in the recovery of numerous artifacts and ecofacts and allowed the construction of a stratigraphic map of the embayment containing the site.

Seven Stemmed projectile points, one Crescent, one bone bead perform, 32 bifaces, eight unifaces, seven utilized flakes, 14,504 bone fragments, 33 charcoal samples, 1,482 pieces of shell, 11 cores, 16,242 pieces of lithic debitage, and 90 other specimens were recovered from eight 1 x 1 meter units. Over 200 lithic tools were collected and/or described and their locations noted during the surface survey. A stratigraphic profile for the embayment was compiled from backhoe trenching, auger hole excavation, and examination of the exposed ditch cut.

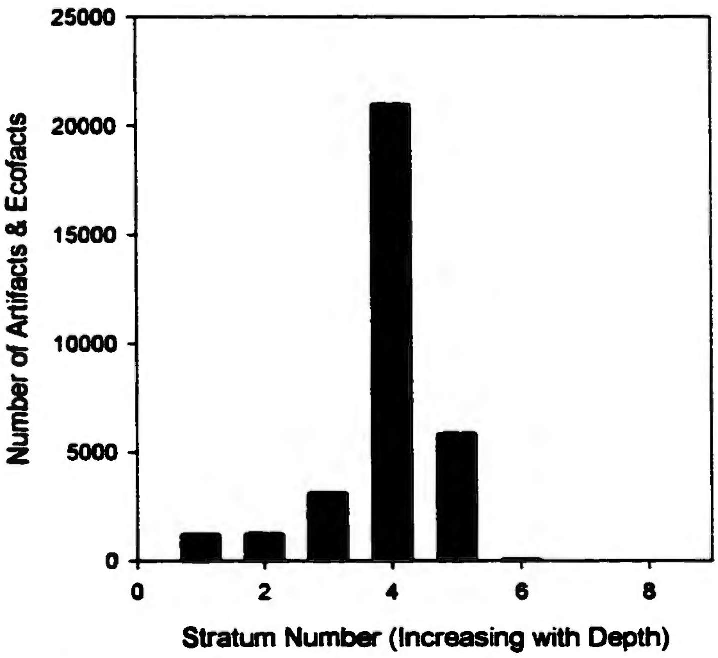


Figure 10. Number of artifacts and ecofacts by stratum.

Excavations were taken to a depth of 130 cmbd and cultural material was found in varying quantities throughout. But the majority of the faunal materials, lithic tools, and debitage were found between 70 and 100 cmbd within Strata 3, 4, and 5, with stratum 4 having the highest concentration (Figure 10).

The artifact distribution was also concentrated horizontally. Figure 11 is illustrative of the relative distribution of artifacts. However, this figure shows only the artifacts discovered *in situ* and is not representative of the number of artifacts recovered from each unit. The horizontal distribution and density of artifacts suggests that one activity area is present, with the southern units A, B, C, D, E, and F containing the most artifacts and density decreasing in the northern units N and O.

Stratigraphy

The stratigraphy of the Weed Lake Ditch site excavation was analyzed and described by Fred Nials, a consulting geomorphologist. His descriptions of each stratum are found in Appendix B and Nials (2000). Overall, the stratigraphic profile of the Weed Lake Ditch site evidences the changing environment of the area from one dominated by lacustrine processes, to that of a dry, wind-dominated regime.

The primary cultural stratum (4) consists of medium sand and bioturbated gravels laid down during a brief highstand or storm surge (Nials 2000). Above the cultural stratum (4), aeolian activity dominates the energy regime, with no other lake activity evidenced, and below it the strata are dominated by lacustrine processes.

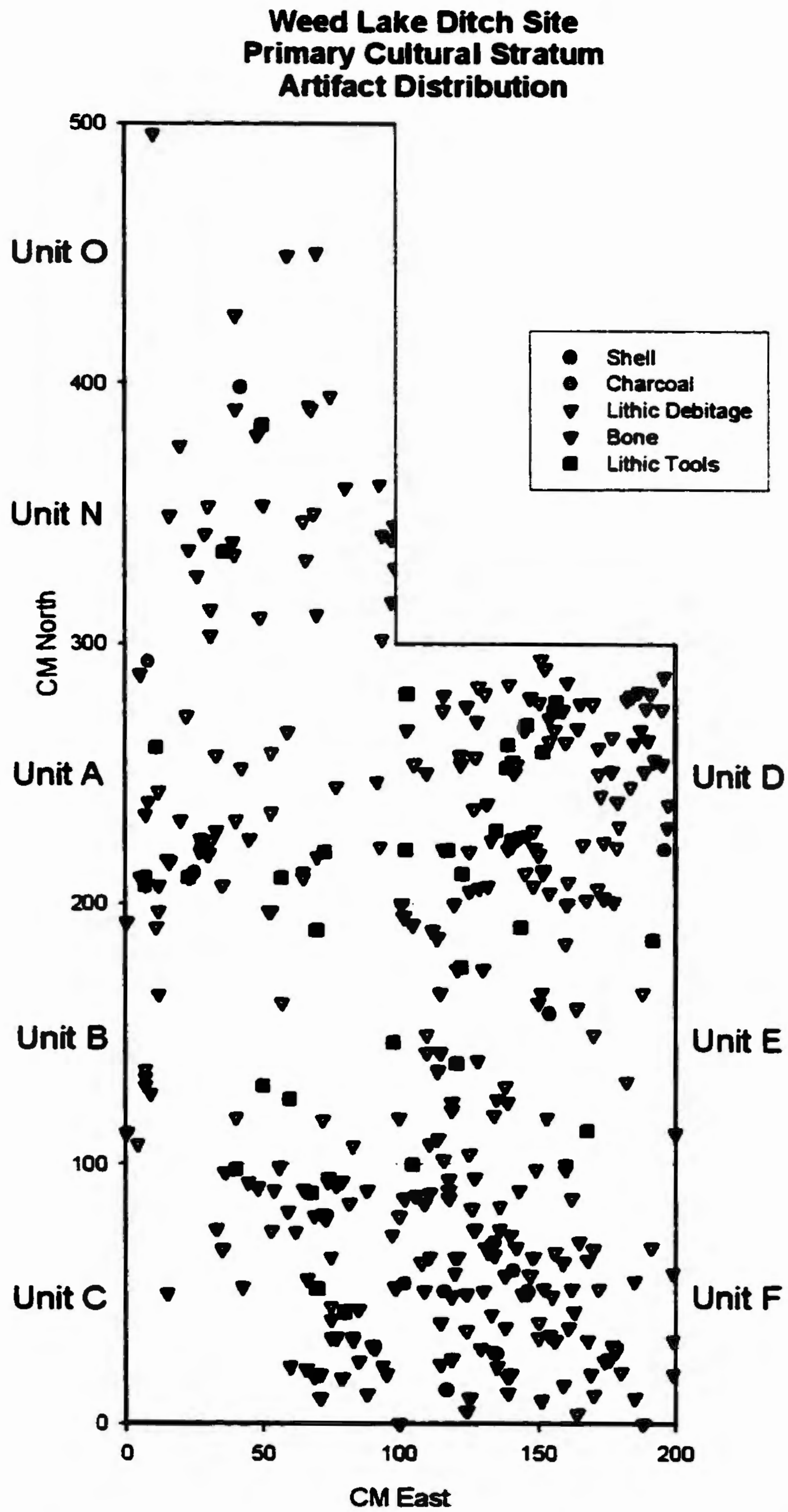


Figure 11. ***In situ*** **horizontal artifact distribution within Stratum 4.**

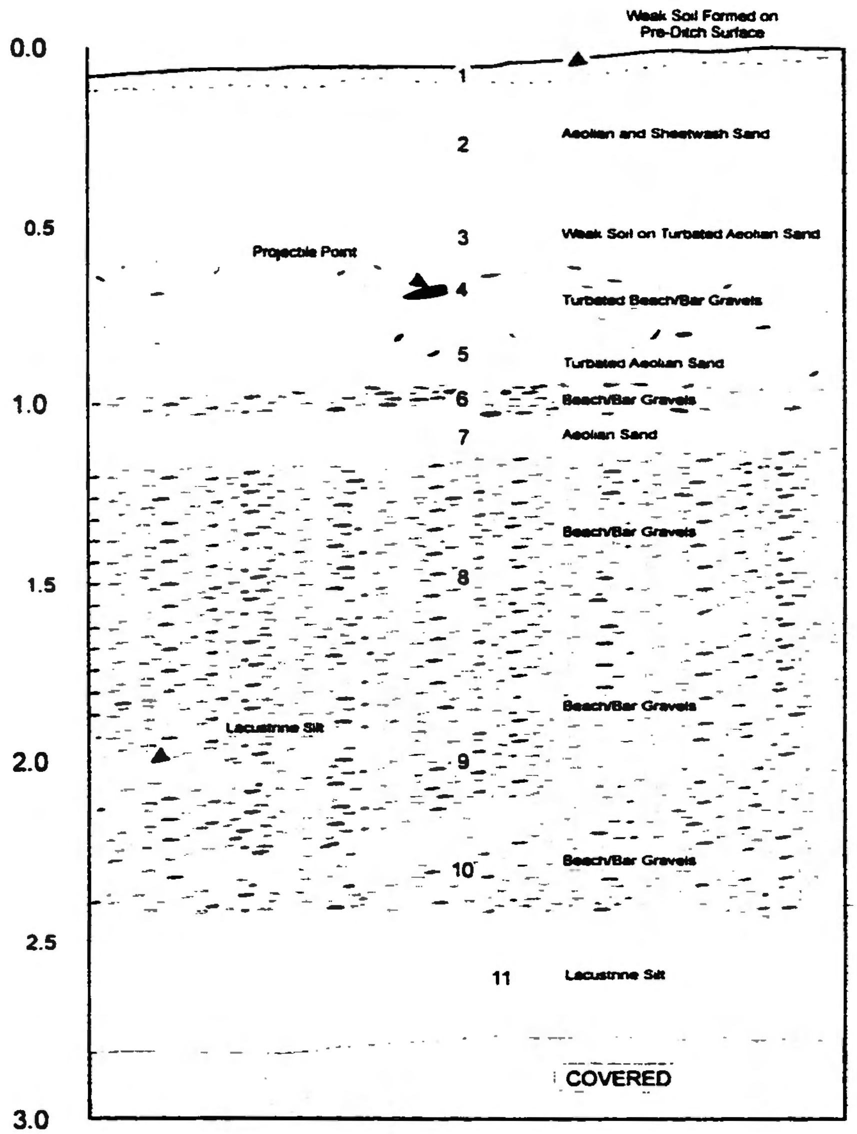


Figure 12. Stratigraphic profile of excavation, depth in meters (from Nials 2000).

A general drying sequence is evident. Lacustrine deposits are at the base of the profile, followed by lake-margin deposits of gravel, which eventually transition into aeolian deposited sands at the top of the sequence. As shown by Figure 12, stratum 1 is a fine to medium aeolian loamy sand with abundant organic material and weak soil formation. Stratum 2 is a silty fine sand deposited by aeolian and localized sheetwash processes. Stratum 3 is aeolian deposited medium sand with weak soil formation. The cultural stratum, number 4, consists of mixed gravel and medium sand. Nials (2000) points out that the well-rounded to sub-rounded discoid-shaped welded tuff clasts found in this stratum are characteristic of beach bars in the area. These randomly oriented clasts are contained within a sandy matrix and their orientation suggests "bioturbation has modified the primary depositional integrity of the deposits. Few clasts, however, show angular edges or disassociated angular fragments, suggesting that burial probably occurred relatively soon after initial deposition - before the fragments could be broken by frost action or by salt crystallization associated with frequent wetting and drying" (Nials 2000). Nials also suggests that this stratum was originally similar in nature to stratum 6, "and probably was deposited by temporarily higher waters associated with a brief rise in lake level, or a storm surge that eroded deposits located lakeward of the site area" (Nials 2000). The medium sands of stratum 5 are interpreted as aeolian re-deposited beach sands, whereas

stratum 6 consists of a thin imbricated gravel deposit that was rapidly covered by the aeolian sands of stratum 5. Importantly, this gravel contained a single *in situ* chert flake. There are two possible explanations for the deposit of stratum 6: either a brief rise in lake level or a storm surge. The wind deposited medium sands of stratum 7 are similar to those in stratum 5 and are interpreted by Nials as being "deposited quite rapidly during a period of temporarily lowered lake level or diminished storm magnitudes" (Nials 2000). Strata 8, 9, and 10 are imbricated gravel beach bar deposits laid down near the shoreline of pluvial Lake Malheur. The stratum found lowest in the profile, number 11, is clay-rich silt sediment of lacustrine origin.

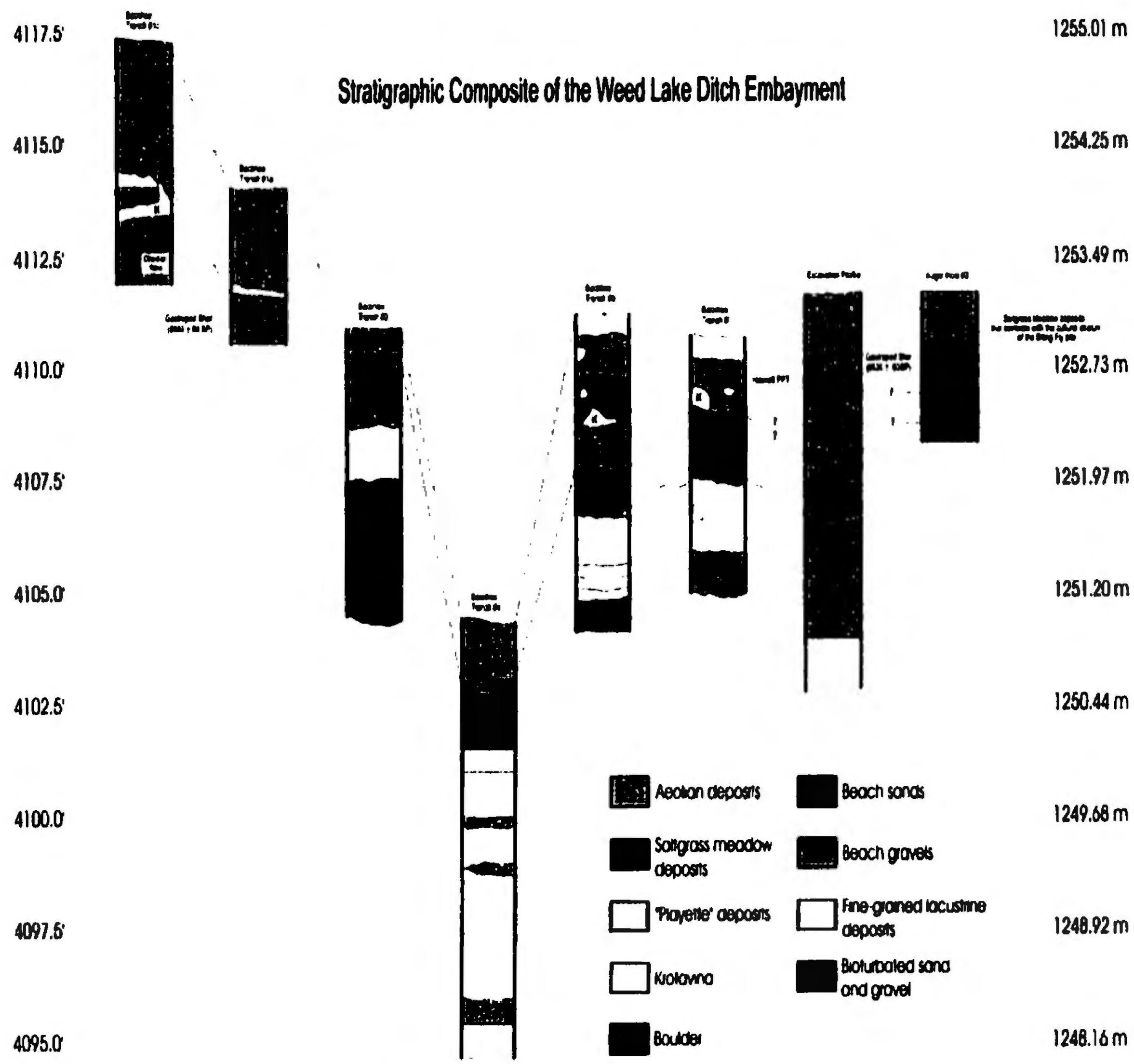
In summary, the stratigraphic profile represents the changing climatic conditions during the late Pleistocene and early Holocene. Lake deposits deepest in the profile give way to a massive shoreline gravel bar, which is topped with aeolian deposited sands with periodic high-water shoreline deposits – the last of which was laid down 9,860 ^{14}C yrs BP. The lake has never made it back to this elevation, and the upper deposits are aeolian in nature with a few periods of sufficient stability for weak soils to develop.

Backhoe Trenches. Fred Nials directed the excavation of four backhoe trenches within the northeastern portion of the embayment containing the Weed Lake Ditch site (Figure 9). Backhoe trench #1 was excavated at the same location from which Gehr (1980) obtained the gastropod shell dating to 8,680 ^{14}C yrs BP. The wall of this trench exposed the last high shoreline of pluvial Lake Malheur represented by the shell sample obtained in 2001 and dating to 9,860 +/- 80 ^{14}C yrs BP. Gastropod shell is also found in moderate amounts within the strata above the last shoreline and interpreted as secondarily deposited shell brought in by aeolian activity, or worked upwards through the profile through animal activity (modern ant activity is a good example). This bioturbated shell, which is believed to be that obtained by the augered sample of Gehr because of the depth at which it is found, is weathered in appearance (white and opaque). The shell sent for AMS dating in 2001 was from a thick, shell supported bed of transparent to semi-transparent gastropods - indicating that it is relatively unweathered. The AMS dated shell bed was also bounded by two imbricated gravel strata representing active shoreline deposits. However, the shell found above the last active shoreline is within aeolian deposits.

Of significant importance, a retouched obsidian flake was also found *in situ* - embedded between large clasts of an active beach deposit and underlying an imbricated gravel shoreline deposit. The rounded gravels, boulders, and coarse sand of the stratum containing the flake stratigraphically correlate to the level of the AMS dated shell.

In 2002, four additional backhoe trenches and three auger holes were excavated (Figure 9). Three of the backhoe trenches were placed between the Biting Fly and the Weed Lake Ditch sites; the fourth was placed south of the gravel-spit bar. The first three trench locations were chosen in order to link the stratigraphic profiles of the Biting Fly and Weed Lake Ditch site, as well as to expose the 8,680 ^{14}C years BP and 9,620 ^{14}C years BP gravel bars previously documented by Gehr. The purpose of the fourth trench was to find dateable marsh deposits that could potentially be linked, temporally and stratigraphically, to the cultural stratum at Weed Lake Ditch. The most suitable place to have excavated such a backhoe trench was on private land, so a less suitable location was settled upon south of the gravel-spit bar and north of the fence line boundary at the site. In addition to the trenches, three auger holes were excavated between the Biting Fly site and the trenches in order to better establish the stratigraphic connection to the Biting Fly site. No other dateable material (i.e., charcoal, bone) was noted in any of the trenches or auger holes.

The stratigraphic relationship of the Biting Fly and Weed Lake Ditch sites was established (Figure 13) along with the stratigraphic sequence of the embayment. These



Compiled from field notes of both Fred Nials and Teresa Wriston
Correlation of four profiles on left by Fred Nials, other correlations made by Teresa Wriston

Figure 13. Strata correlation of selected backhoe trenches and the excavation profile.

correlations are supported by the radiocarbon dates obtained from the cultural stratum, backhoe trench #1, and a marsh/wet meadow deposit. The cultural stratum of the Biting Fly site is stratigraphically above that of the Weed Lake Ditch site, within and above a saltgrass meadow deposit laid down after the pluvial lake had receded.

It is important to note that evidence for human occupation of the active shoreline was also found in the form of two *in situ* flakes. One chert flake was found within the imbricated gravel underlying the primary cultural stratum at the Weed Lake Ditch site, and one large obsidian flake was found within the high energy beach gravel shoreline deposits laid down by the last highstand of pluvial Lake Malheur and exposed in the first backhoe trench.

Radiocarbon Dating

Although both bone and charcoal were submitted for radiocarbon assay, they proved too degraded to provide reliable dates. As a result, all of the dates obtained from the Weed Lake Ditch site are derived from gastropod shell retrieved from various stratigraphic units, except for one charcoal date that was thrown out as intrusive root burn material dating to modern times. A total of four dates were obtained (see Figure 14; Appendix A: Table 4).

A sample retrieved from backhoe trench #1 at the mouth of the embayment consisted of nearly clear, hence relatively unweathered, *Vorticifex effusa* shell that provided a revised date of 9,860 $\pm$ 80 ^{14}C yrs BP (Beta-161511) for the last highstand of pluvial Lake Malheur (an 8,680 ^{14}C yrs BP date was obtained on gastropod shell from near this location during the late 1970s). A sample obtained south of the site from the drainage ditch cut through a marsh/wet meadow deposit, which is thought to stratigraphically correspond to the cultural stratum, was dated using weathered (opaque) *Gyralus parvus* shell extracted from a sediment sample. The marsh/wet meadow sample is 9,540 ± 80 ^{14}C yrs BP in age (Beta-172009), slightly younger than the cultural stratum. A *Lymnea* shell from the cultural stratum was retrieved from between 80 and 90 cmbd and dated to 9,820 ± 60 ^{14}C yrs BP (Beta-172010). This date and the stratigraphic associations of the cultural stratum suggest that its habitation occurred immediately after the last highstand of pluvial Lake Malheur. Gehr (1980) dated a sample from a gravel bar between the Weed Lake Ditch site and the present Harney Lake to 9,620 ^{14}C yrs BP.

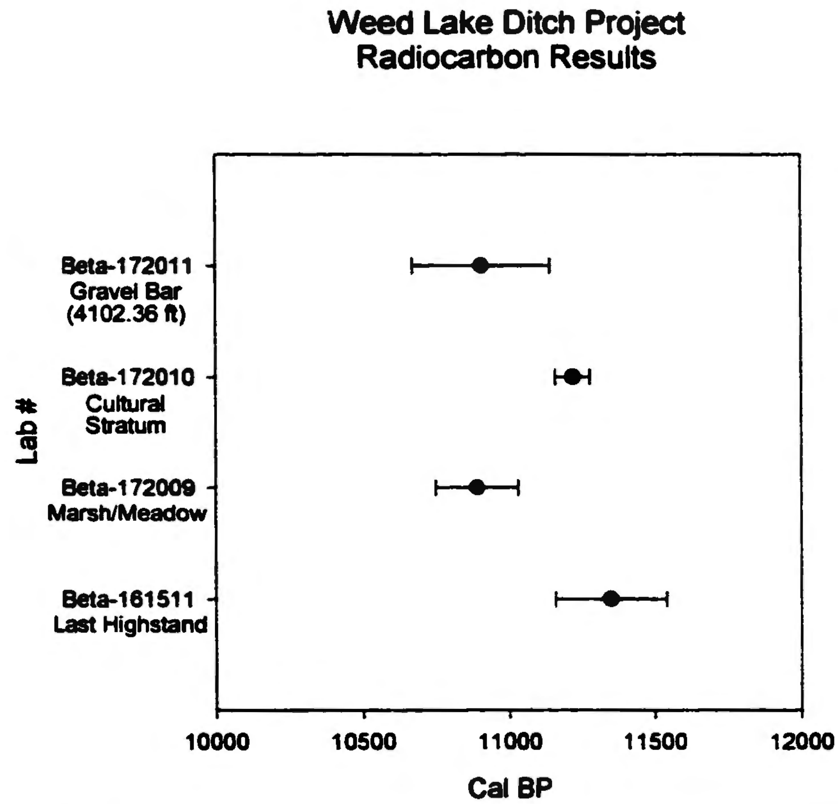


Figure 14. 2 sigma calibrated radiocarbon ages of shell samples.

A sample of weathered (opaque) *Fontelicella hendersoni* obtained from the same shell bed by the SARF crew was dated to 9,550 ± 60 ^{14}C yrs BP (Beta-172011). This gravel bar is located stratigraphically *below* the gravel bar that the site is situated upon, and should be older than ca. 9,900 ^{14}C yrs BP (see environmental discussion). As previously discussed, this date reversal could be caused by the diagenetic changes of this opaque, weathered shell bed.

Features

One amorphous pink stain straddling the western margins of units E and F was recorded as a possible hearth remnant. Within strata 3 and 4, the possible feature was only recognized when cloud cover overtook the site – providing ambient light for color saturation. Unfortunately, rain forced researchers to discontinue the stain's excavation until the next day. The photographs taken on the following day, which was sunny, show little color differentiation. In addition, the feature, which was missed in the 2000 excavations, (it continued into unit B) contained charcoal. However, this charcoal dated to modern times (see chronology section). Fire-affected (pinkened) sediment was collected for future analysis. Whether this recorded feature represents the remains of a hearth or root burn is unknown. No further attempts at dating the other charcoal samples obtained from stratum 4 have been made because of their possibly intrusive nature.

A second feature was recorded during excavation in unit D. This feature consisted of several hundred flakes within an oval depression measuring approximately 30 x 40 cm. The sediment was noted as root-rich and the depression had a thin lense of calcium carbonate at its lower boundary.

Lithics

Projectile Points. One Haskett-Type II Stemmed projectile point fragment, three Haskett-Type I Stemmed projectile points and fragments, one Crescent, and three Stemmed projectile point fragments were recovered from the excavations (Figure 15).

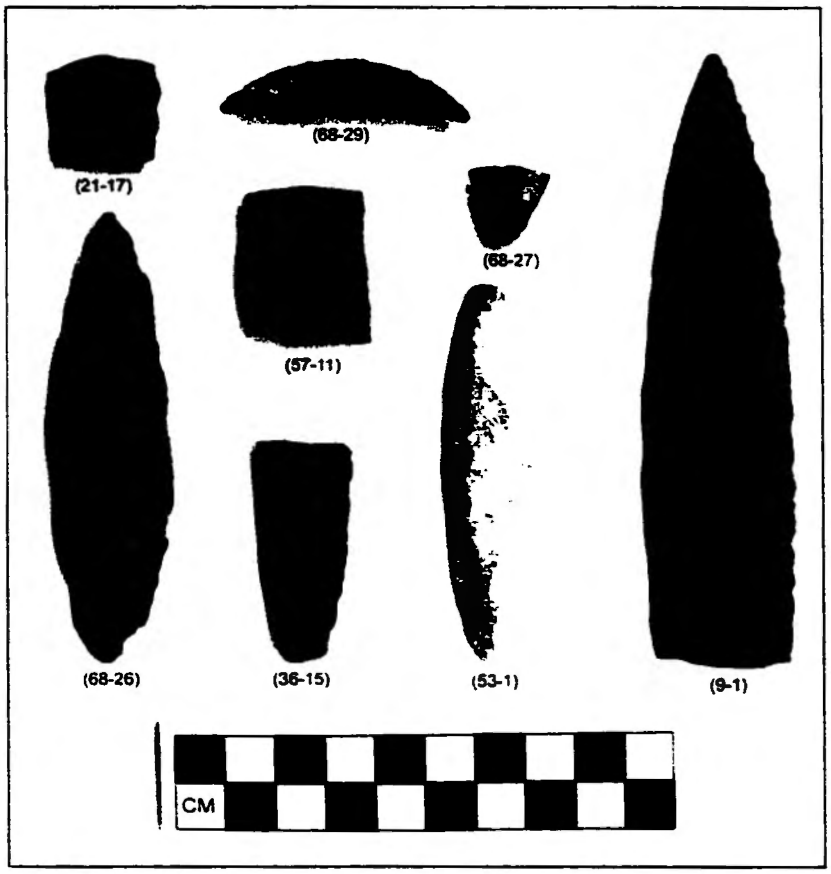


Figure 15. Temporally diagnostic artifacts from the excavation.

The base is missing from the Type II Haskett point (Figure 15, 9-1), which is made of dark gray rhyodacite; however, grinding is identifiable along 1.5 cm of its lateral proximal margins. The maximum dimensions of the Haskett are 13.1 cm in length, 3.05 cm in width, and 0.95 cm in thickness. The point exhibits a regular flaking pattern and a lenticular cross-section. XRF analysis has identified the specimen material as identical to that of the Venator lithic source located near the North Fork of the Malheur River. The artifact was found *in situ* eroding from the eastern wall of the ditch cut at 84.75 cmbd in Unit A and within stratum 4. This is the projectile point that initiated the excavation at the Weed Lake Ditch site.

The mottled tan cryptocrystalline silicate (CCS) Type I Haskett Stemmed projectile point fragment (Figure 15, 53-1) measures 8.05 cm in length, 2.0 cm in width, and 0.8 cm in thickness. The distal end is fractured. The point has a convex cross-section and regular flaking pattern. Light lateral grinding is perceptible along 3.2 cm of the tapered stem and its narrow basal margin is straight. This artifact was recovered from unit D at 81 cmbd and within stratum 4. The second Type I Haskett fragment (Figure 15, 36-15) is a basalt base, measuring 4.7 cm in length, 1.9 cm in width, and 0.8 cm in thickness. The heavily ground lateral margins taper to a straight base and a regular flaking pattern is evident. The proximal edge has a snap fracture and the cross-section has a median ridge on both surfaces. This artifact was recovered from the northeast quadrant of Unit C, within stratum 4 at 84.5 cmbd. The third projectile point (Figure 15, 68-26) was tentatively identified as a Haskett Type I after comparison with photos of Haskett points from the type site by Butler (1965) and is manufactured from fine-grained basalt. The artifact is complete and tapers to a point on both its proximal and distal margins. The maximum dimensions of the Haskett are 9.6 cm in length, 2.4 cm in width, and 0.95 cm thick. It is moderately ground along 3.4 cm and 3.6 cm of its proximal lateral margins and shows evidence of reworking. The artifact is convex in cross-section and has a regular flaking pattern. The artifact was recovered from Unit E at 99.5 cmbd within stratum 4.

A single Crescent (Figure 15, 68-29) was recovered from the excavation in Unit E, within stratum 4 and between 95 and 100 cmbd. It is manufactured from a CCS flake that has been bifacially sharpened along all margins. The maximum dimensions of the artifact are 5.0 cm in length, 1.15 cm in width, and 0.4 cm in thickness.

A small mahogany obsidian contracting Stem base (Figure 15, 68-27) was found while screening the sediment removed from the northwest quadrant of unit E. Fractured on its proximal end, this point measures 1.6 cm in length, 1.6 cm in width, and 0.5 cm in thickness and has moderate grinding on the tapered margins. It has a regular flaking pattern and a lenticular cross section and was found in stratum 4 at between 62-67 cmbd. XRF analysis has identified the obsidian as from Glass Buttes 6, which is located 52 miles northwest of the excavation site. The second Stem base fragment (Figure 15, 21-17) was manufactured from fine-grained basalt and is snap fractured on both its proximal and distal margins. It has lightly ground lateral margins, a regular flaking pattern, and convex cross-section. Its maximum dimensions are 2.25 cm in length, 2.25 cm in width, and 1.0 cm thick. The artifact was found during the dry screening of sediment excavated from stratum 4 of Unit B at a depth of 90-100 cmbd. A Stemmed projectile point base (Figure 15, 57-11) found near the surface within stratum 1 of Unit E, is manufactured from rhyodacite. The fragment has a regular flaking pattern, lenticular cross-section, and lightly ground lateral margins. The proximal and distal margins have been hinge-fractured.

Bifaces. In addition to the projectile points previously described, thirty-two bifacially worked artifacts and eleven cores were recovered from the Weed Lake Ditch excavation. Thirty-one of these artifacts are composed of cryptocrystalline silicate

(CCS), 11 are of obsidian, and one is basalt. All stages of bifacial reduction are represented (Figure 16) with 12 Stage I, eight Stage II, eight Stage III, 12 Stage IV, and three Stage V bifaces. The majority of the bifaces are fragments and several exhibit pot-lid fractures and crazing resulting from exposure to extreme temperatures. Two of the fragments refit, but were recovered from different depths within two adjacent 1 x 1 meter units (one was found in the screen for 70-80 cmbd in Unit O, and the other in the middle of unit N at a depth of 88 cmbd), evidencing the degree of bioturbation present within the cultural stratum.

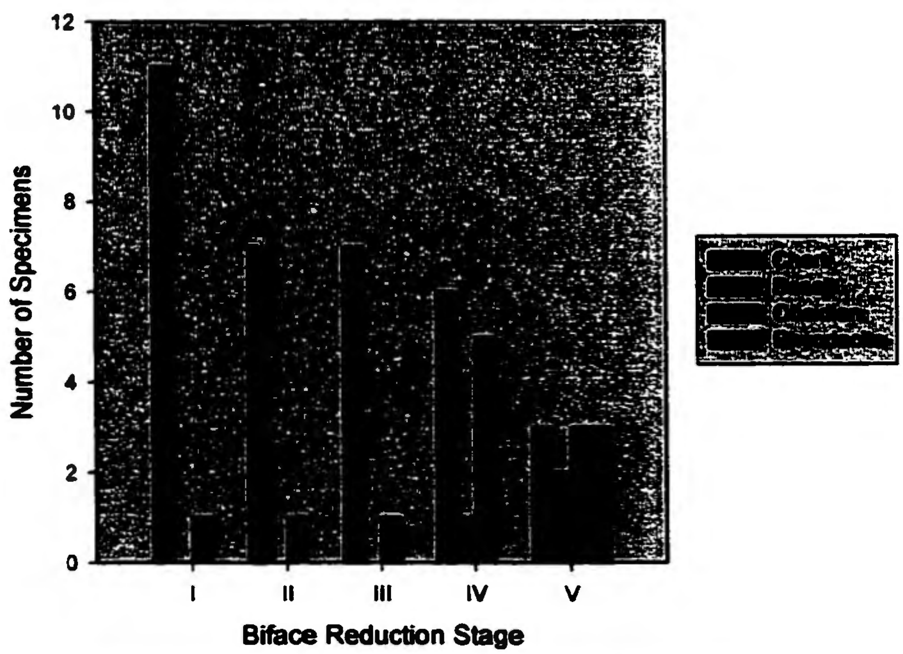


Figure 16. Number of bifaces of each stage by material type.

Figure 16 shows that a distinct difference in material type and stage of lithic reduction is discernable. The majority of early stage bifaces are of locally available chert, whereas the later stage bifaces (which include the projectile points) are of more varied lithic material.

Other Tools. Unifaces (five obsidian, one basalt, one CCS), one scraper (obsidian), and utilized flakes (five obsidian and two cryptocrystalline silicate) are also present in the tool assemblage. The scraper is a formal tool and manufactured from Gregory Creek obsidian. One of the unifaces sourced to Tank Creek, one to Burns obsidian source, one to Glass Buttes 3, and one to Big Stick (Skinner 2002; Appendix A; Table 8).

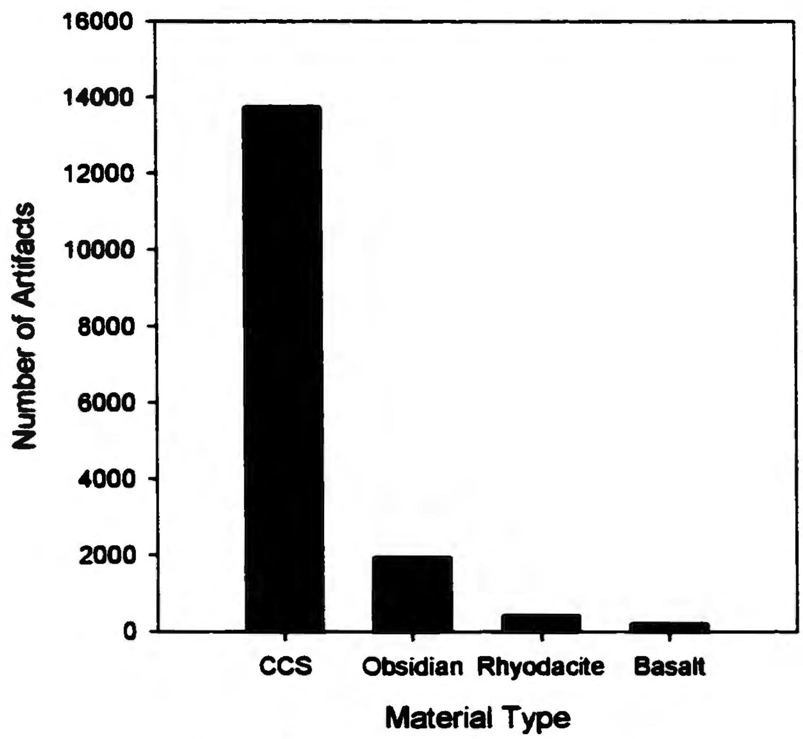


Figure 17. Lithic debitage by material type.

Debitage. A large lithic assemblage was recovered in the excavation of the eight 1 m^2 units at the Weed Lake Ditch Site. Lithic debitage from five of the eight units was analyzed. Cryptocrystalline silicates (84%), obsidians (12%), and rhyodacites (2.5%)

comprise 98.5% of the debitage (Figure 17). The remaining 1.5% consists of fine-grained basalt, petrified wood, welded tuff, and pumice. The abundance of cryptocrystalline silicate (CCS) is likely due to the proximity of the Eagles' Nest Chert procurement area, located less than 3.5 miles (2.17 km) east-northeast of the site.

Lithic debitage was separated into seven different categories based on the presence or absence of a bulb of percussion and how much cortex, if any, remained on the artifact (Figure 18). These categories include: primary (I) or decortication, flakes

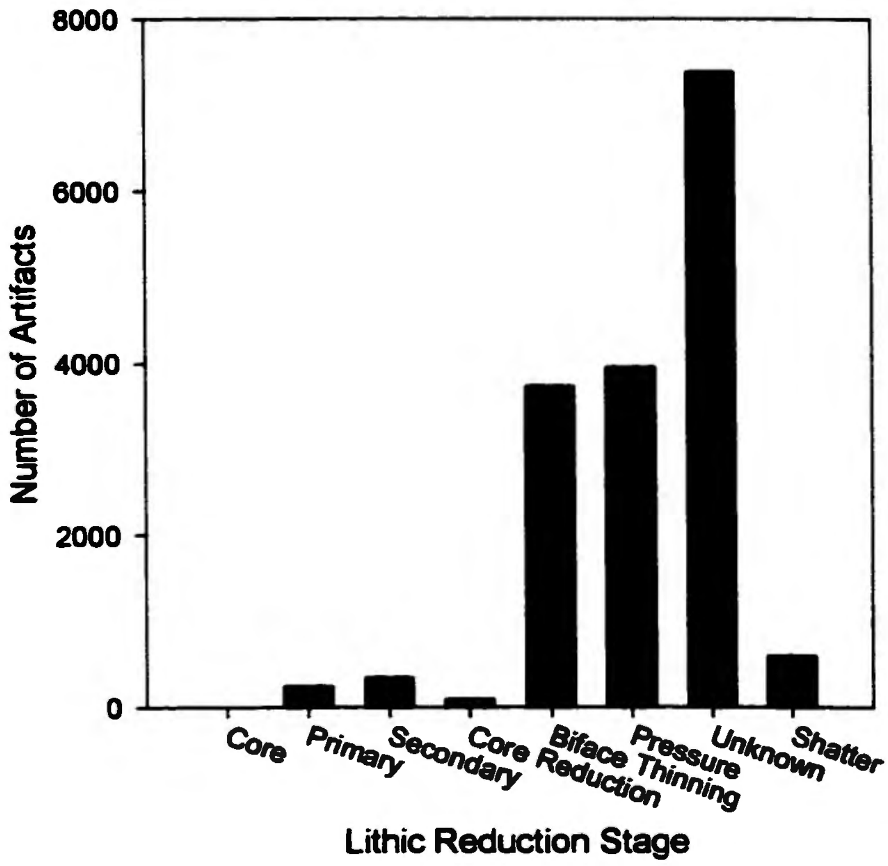


Figure 18. Debitage analysis results.

(dorsal surface > 50% cortex), secondary (II) flakes (dorsal surface remains < 50%

cortex), bifacial thinning flakes (no cortex remains on the dorsal surface, bulb of percussion present), core reduction flakes (cortex remains on platform), pressure flakes (complete, < 50 mm in maximum diameter, no cortex), shatter (angular with no bulb of percussion), and unknown (no cortex remaining, incomplete, no bulb of percussion).

Bifacial thinning, pressure, and unknown (generally referred to as tertiary) flakes dominate the lithic assemblage. This finding, when coupled with the fact that locally available chert heavily dominates the debitage and early stage biface assemblages, suggests that this site location was inhabited during the intermediate stages of lithic reduction and retooling and is associated with the discard of expended tools and projectile points brought here from other areas. A complete breakdown of the number of debitage by material type, stage, and stratum is available in Appendix A: Tables 6 and 7.

Faunal Remains

Modified Bone. A single bone-bead preform (Figure 19) was discovered in the wet screen of stratum 4 sediment from Unit F between 74.5 and 79.5 cmbd. The artifact is composed of two segmented sections (beads) created by scoring a rounded long bone shaft sliver. The object is 3 mm in diameter and 5 mm in length. The segments are roughly equivalent in size and it is evident that two other segments had been created and snapped off each side. The scoring tapers down to the center, which has not been drilled through. Unfortunately, most beads are probably not recovered because they are smaller than the screens used. I

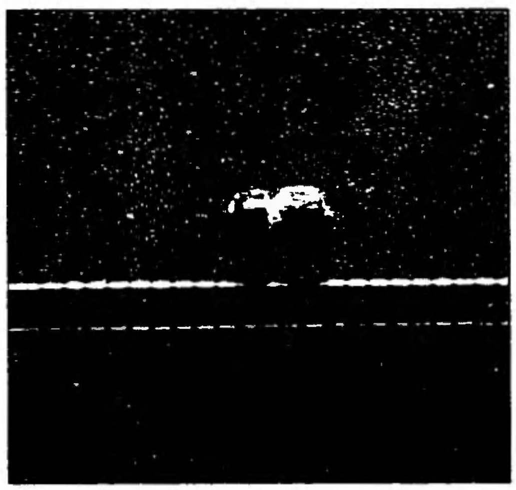


Figure 19. Bone bead preform.

have no doubt that the one from the Weed Lake Ditch site would have been lost through the standard one-quarter or one-eighth inch screens; luckily it was from one of the units selected for wet screening through one-sixteenth inch screen. Apparently, there were bone beads recovered from two early sites previously discussed. Bedwell recovered some bone beads from Fort Rock Cave and Connley Caves (Jenkins and Wimmers 1994), but their stratigraphic and cultural contexts are questionable (Jenkins and Wimmers 1994:110), and Cowles (1959) recovered a variety of bone beads reportedly from above 1 ½ feet (this is also the level that the Cougar Mountain Cave point appear), but the lack of documentation and stratigraphic control at this excavation makes any correlations tenuous at best. However, none of the beads shown in Cowles report (1959) resembles the bone beads/preforms found at Sentinel Gap or the Weed Lake Ditch site. Fortunately, the excavation of the Sentinel Gap site, a Haskett tradition site located in Washington has beads (Figure 20) very much like the one recovered from the Weed Lake Ditch site from good stratigraphic contexts dated to 10,200 ^{14}C yrs BP (Galm and Gough 2002).

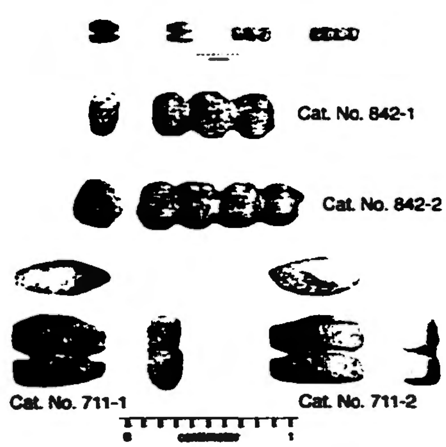


Figure 20. The bone beads and preforms recovered at the Sentinel Gap site (J. Galm and S. Gough 2003, personal communication).

Bone. A total of 14,504 small pieces of fragmented vertebrate bone were recovered, of which only 560 specimens were identifiable to species, genus, or family (see Appendix A: Table 9; Livingston 2003). Of the latter, 176 were obviously intrusive consisting of light colored rodent and jackrabbit bones (the rest of the bones are a dark brown color). These intrusive bones were removed from the tally represented in Figure 21. Wetland adapted bird species heavily dominated the total number of specimens (Figure 21). Identified types of wetland birds present in the assemblage include: Western Grebes, grebes, American Coots, coots, goose-size birds, ducks, and rails (Table 2). The second most common class of faunal material was from rabbits and hares – which still inhabit the immediate area. Four canid, or canid-sized, bones were recovered, as were two artiodactyl molar fragments.

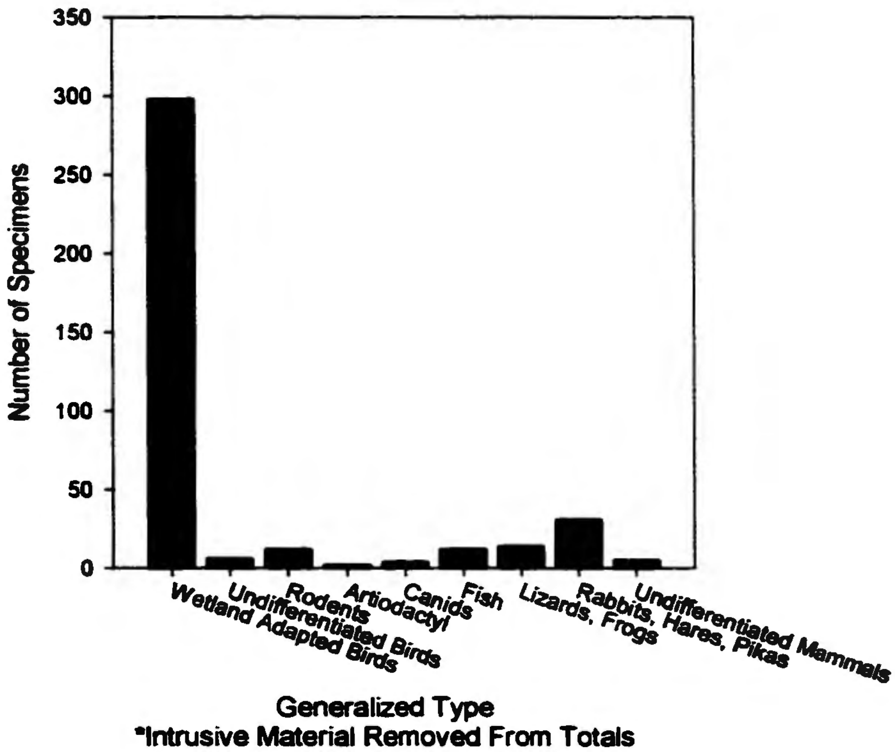


Figure 21. Identified faunal material by type.

All of the bone recovered from below stratum 3 is of nearly identical color - dark brown, with root etching providing the only differentiation. No evidence of burning is discernable. A 32.4 grams bone sample recovered from Unit A between 80 to 90 cmbd was submitted to Beta Analytic for radiocarbon assay. However, the sample proved to be too degraded to obtain a reliable age. The bone is at least partially permineralized, and although this facilitates preservation, not enough collagen remains for a radiocarbon date.

Table 2. Waterfowl species recovered from the excavation (extrapolated from Livingston 2003).

I.D.	Taxon	NISP	Totals by type
Coot	American Coot	86	
Coot	undifferentiated	125	
Coot	*subtotal*		*211*
Grebe	Western Grebe	25	
Grebe	undifferentiated	37	
Grebe	*subtotal*		*62*
Duck	large	9	
Duck	medium	8	
Duck	*subtotal*		*17*
Goose	undifferentiated	7	
Goose	*subtotal*		*7*
Rail	small-size	1	
Rail	*subtotal*		*1*
Wetland Birds		**Total**	**298**

Although no direct evidence such as butchery cut marks exists that would undeniably prove that the faunal material recovered is associated with the cultural component, the distribution of artifacts and bone correspond directly (Figure 22), leading me to surmise that the faunal assemblage results from human activity. It is possible that

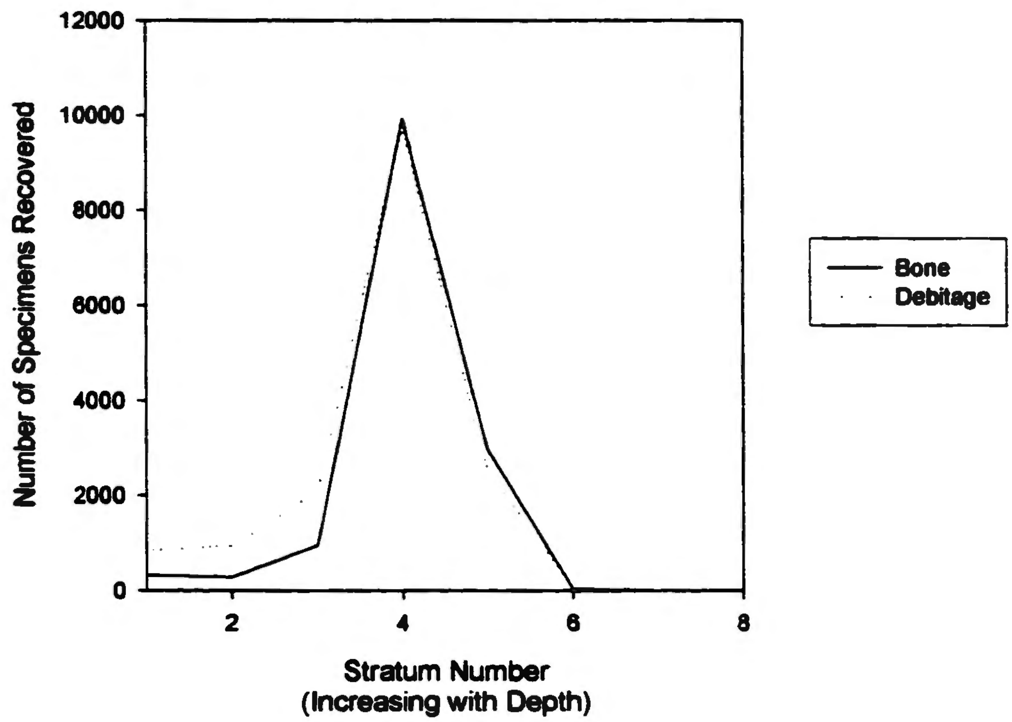


Figure 22. Distribution of Bone and Debitage by Stratum.

the lake concentrated bone by depositing it along its shoreline. However, the thin lense of shingled gravel (stratum 6) found below the cultural stratum, and the large bar below that (stratum 8), had little to no faunal material (Figure 12). Therefore, the faunal material recovered from stratum 4 is believed to result from cultural activity rather than from natural processes.

Any interpretation of the faunal material by animal type has to be tempered with the realization that these numbers are not minimum number of individuals (MNI), but are instead the number of individual specimens (NISP) present. However, that being said, a comparison of the animal types represented has interesting implications for subsistence practices of the inhabitants of the Weed Lake Ditch site.

All of the waterfowl present in the assemblage are known to either overwinter in the area today or arrive in early spring (Malheur National Wildlife Refuge 2003). In addition, the numerous species of migratory waterfowl that use the refuge in the summer and late spring during modern times are not represented in the faunal assemblage. This suggests a winter to early spring occupation for the Weed Lake Ditch site based on the faunal evidence.

Shell. Nearly 1500 pieces of gastropod shell were recovered, primarily from stratum 4. A total of 212 specimens were identifiable to genus or species from the excavation. Of the identified specimens, the majority consists of *Gyralus parvus*, a marsh adapted species (Gehr 1980). The other identified specimens consists of *Lymnea* (marsh-adapted), *Planorbella subcrenata* (marsh-adapted), *Valvata humeralis* (marsh-adapted), *Fonticella hendersoni* (open-water adapted), and *Vorticifex effusa* (open-water adapted, predominates in backhoe trench #1 in the high shoreline deposit) (Figure 23).

By studying the distribution of these shells, and which types are found where, it is possible to recreate the local environment (water level) that existed where they were deposited, for any change in species location may indicate paleoenvironmental change (Carambelas and Elston 1992:51). Little shell is found above stratum 3, and the vast majority of shell was recovered in stratum 4 and 5. Marsh adapted gastropod species (Gehr 1980) dominate the recovered material from the Weed Lake Ditch excavation, suggesting a shallow water nearshore environment at the time of deposition. In contrast, the dense shell bed within the active shoreline deposit found in backhoe trench #1 consisted predominately of *Vorticifex effusa*, an open-water gastropod.

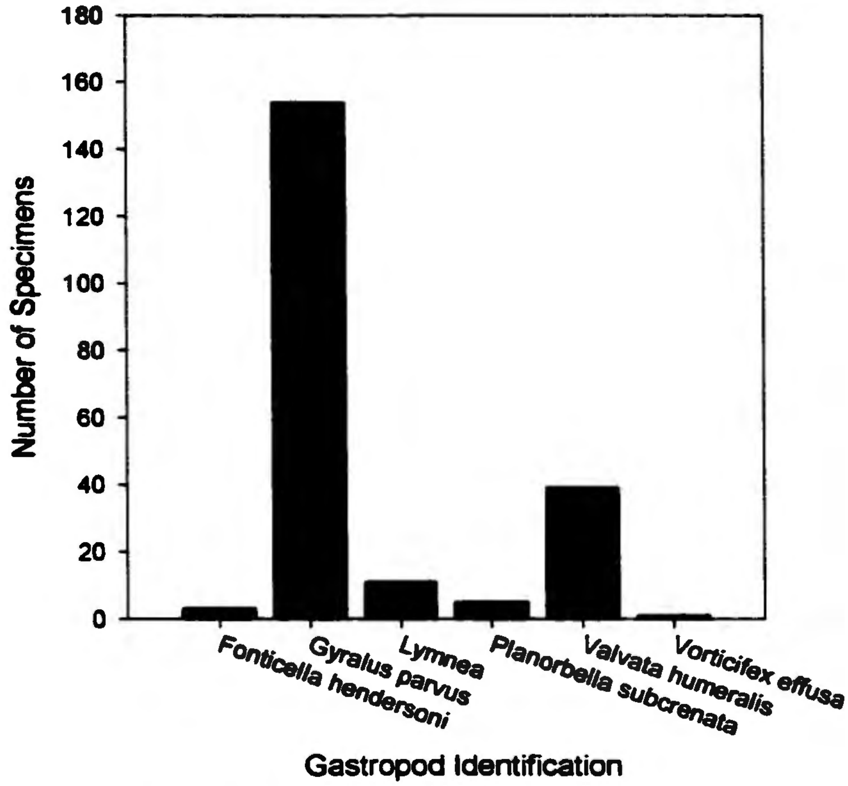


Figure 23. Identified gastropod specimens by species and abundance.

Surface Survey

Previous investigators, including Gehr (1977, 1980), Enneberg and Bright (1983), Christian (Clifford 1997), and Branigan (2000) noted Stemmed projectile points and fragments, Crescents, blades, a knife, and over a thousand pieces of lithic debitage strewn across the gravel bar upon which the Weed Lake Ditch site is situated. In all of the reports, amateur artifact collecting is noted as having a significant impact and the area is a known destination of collectors. Despite the previous collecting activities on site (both legitimate and illegitimate), a surface survey conducted during 2001 located and described a total of 229 tools (Figure 24). Of these, 139 were collected either because they were considered diagnostic, made of obsidian (which can be sourced), or representative of an artifact type. Of the 229 artifacts, 53 are projectile points or fragments, 157 are bifaces of various stages of manufacture, 10 are utilized/retouched flakes, five are cores, and three are unifaces. One metate was noted and described, but not collected. The temporally diagnostic projectile points range in age from early Holocene to Late Prehistoric with Concave Base (n = 6), Stemmed (n = 34), Crescent (n = 4), Elko and mid-sized notched (n = 4), and Rosegate or small notched (n = 5) projectile point types represented.

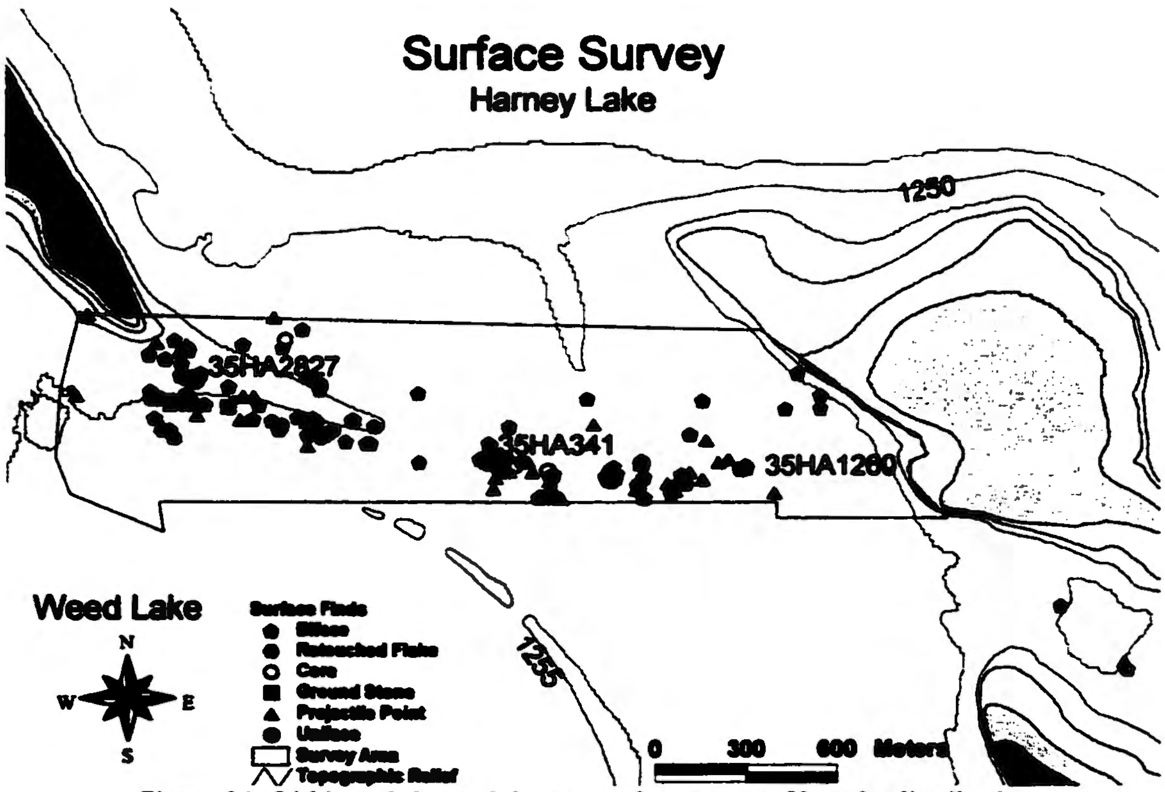


Figure 24. Lithic tools located during surface survey. Note the distribution in relation to the gravel spit bar.

These artifacts are concentrated on the gravel-spit bar that the Weed Lake Ditch site is located upon. The well-drained nature of the bar may have been attractive during wet conditions. In addition, the view of the saltgrass meadows and/or marshes and meadows that were found here during the early Holocene would have proven advantageous in hunting game (Nials 2000, personal communication). During the site occupation, the bar would have provided quick access to both the open water resources of pluvial Lake Malheur to the north and the wet meadow and marshes found in the higher Weed Lake Flat to the south (Gehr 1980; Nials 2001, personal communication).

XRF Analysis

A total of 27 obsidian and rhyodacite artifacts were submitted to Northwest Research Obsidian Studies Laboratory for XRF analysis. All but four of these samples were from the primary cultural stratum (4). Of the remaining four samples, one was an obsidian retouched flake found *in situ* within the high energy deposits created during the last highstand of pluvial Lake Malheur. One obsidian Stemmed projectile point recovered by Keith Gehr in the late 1970s from the wall of the ditch within 30 meters of the excavation was submitted, as were two surface finds. The 27 samples were from 14 different sources (Skinner 2002) – all located within 89 miles of the site (Figure 25). Most of the sources were found north of the site, around the periphery of the Harney Basin and within the nearby uplands. Two sources, Venator and Gregory Creek, are found outside of the hydrographic Great Basin, near the head of the North Fork of the Malheur River that drains into the Columbia River system.

Lithic Sourcing and Subsistence Pattern. With sufficient lithic source locations, a minimum extent of the foraging territory of past peoples can be established in instances where trade of lithic material is unlikely (Jones et al. 2003:8-9). In the northern Great Basin, the abundance of high quality lithic material (obsidian and chert) and low population density likely discouraged extensive trading of this commodity. Therefore, the peoples that occupied the Weed Lake Ditch site probably visited the sources of obsidian that are found to the north, east, and west of the Harney Basin in both upland and lowland settings. However, no direction of travel can be ascertained from plotting the stage of reduction for each sourced artifact (Figure 25).

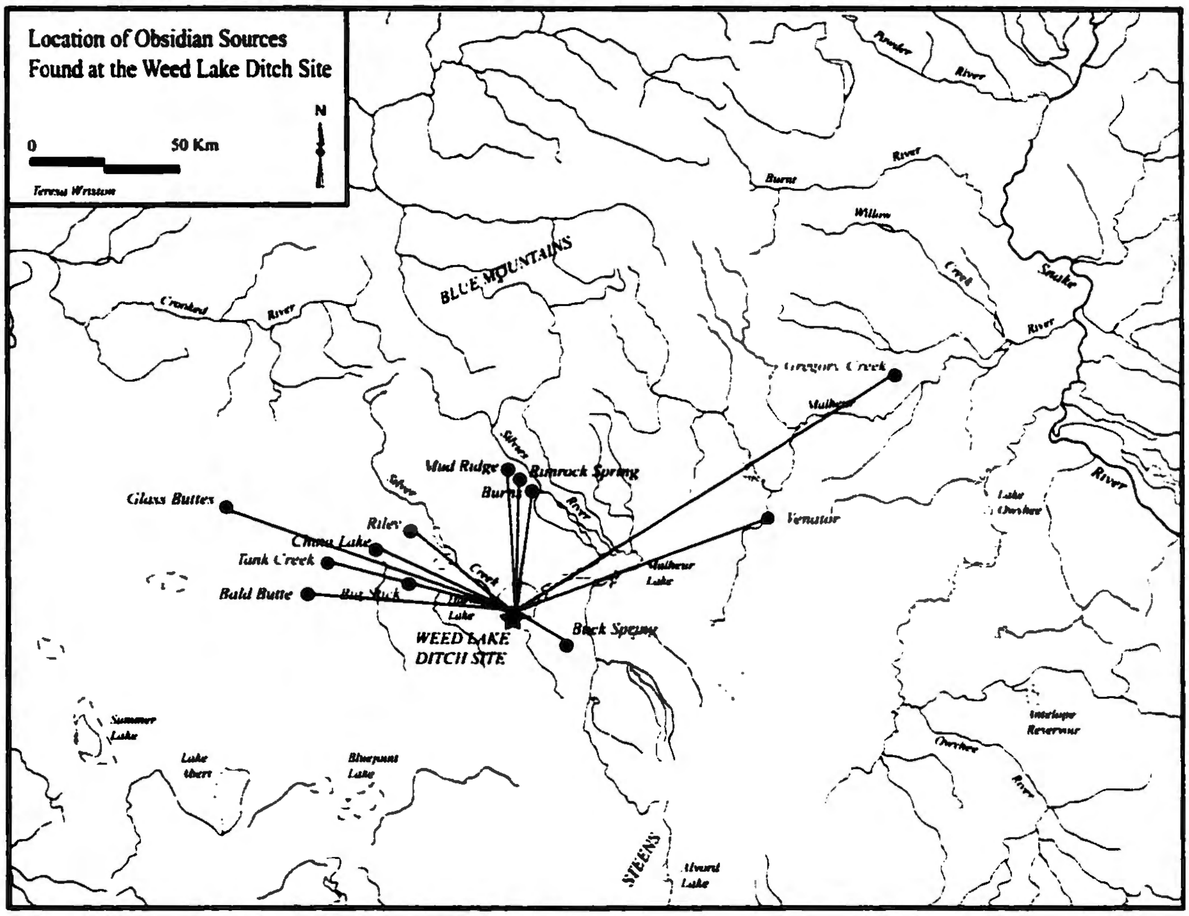


Figure 25. Obsidian source locations of artifacts excavated from the Weed Lake Ditch Site.

The high number of extralocal sources (11 of the 12 sources identified for the total of 22 samples) in the lithic assemblage also suggests high residential mobility.

> As residence time increases, there should be a corresponding increase in the numbers of tool items discarded at a site simply because people deplete more of their tool and raw material inventories during longer average stays. As a result, artifacts would be less likely to "travel" as far from source areas than if occupations were briefer. This suggests, then, that extralocal source diversity may serve as a proxy for residence time; as residence time increases, we expect a corresponding decrease in source diversity [Jones et al. 2003:25].

This is especially compelling because of the hypothesized winter season of occupation for the Weed Lake Ditch site and suggests that the occupants of the site were not caching food supplies for winter consumption as was done in later times. Further discussion of this point can be found in the following section.

CHAPTER 7:
DISCUSSION

Before concluding, I want to discuss some of the general patterns that have emerged from the analysis of the data in more detail. In addition, I include a comparison of the findings between the Weed Lake Ditch and the nearby Nials site in order to help clarify the ways subsistence and technology changed during the hypothetical ca. 1600-year time span that separates the two occupation periods of the sites.

Season of Occupation. There are several lines of evidence that indicate the Weed Lake Ditch site was occupied during winter or early spring months, including ethnographic analogy, the types of faunal material present, and the formation of gravel bars and associated storm surge deposits created by winds and waves coming from the north.

The Harney Valley Paiute, or *Waada* Eaters, maintained a seasonal cycle of resource exploitation until historic times. During winter months, they fished, and hunted waterfowl and game near Malheur and Harney Lakes, which supplied supplemental food to that previously cached near the winter habitation site (Couture et al. 1986; Couture 1978; see also Jenkins et al. 2000).

The modern migration patterns of the types of waterfowl present in the faunal assemblage of the Weed Lake Ditch site, including grebes, coots, ducks, and geese, and the noted absence of any of the many migratory species that only inhabit the lake during the late spring and summer, suggest that the Weed Lake Ditch site was occupied during the winter or early spring months. All of the water-adapted birds present in the assemblage are known to either over-winter in the area in modern times, or arrive in the early spring (Malheur National Wildlife Refuge 2003).

The well developed gravel bars found along the southern shore of Malheur and Harney Lakes testify to the power of winter storms, whose strong north winds create waves with enough force to move the welded tuff gravels that make up the bars. The Weed Lake Ditch site is situated upon such a bar, and its cultural material is mixed with a storm surge or brief highstand deposit of shingled gravels that have subsequently been bioturbated (Nials 2002, personal communication; see also Nials 2002; Gehr 1980). The fact that people occupied the bar immediately following a storm surge deposit of gravel, left the artifact assemblage, and that it was still moist enough to be bioturbated with sand and gravel before being covered over, supports the hypothesis that it was a winter occupation.

Haskett Tradition. The outline of the Haskett projectile point is generally similar to that of Agate Basin and Hell Gap types of the Great Plains, and speculation for a common ancestral form of the three exists (Sargeant 1973). Amick (1996) has suggested that the Haskett point is the only one of the Great Basin Stemmed points that has a sharp enough tip and blade margins to penetrate the tough hide of bison, widen the cut, and allow the projectile and shaft to continue onward into the carcass to kill the animal (Frison 1991; Amick 1996; Beck and Jones 1997). Other forms of Great Basin Stemmed projectile points all show heavily battered and rounded edges and tips, including Cougar Mountain, Parman, Lake Mojave, and Silver Lake types (Beck and Jones 1997:202).

In looking at the photos of Haskett types and the others mentioned, it becomes a problematic task to differentiate them, in part because of the wide diversity of forms first characterized as Haskett by Butler (1965). Although he recognized two distinct types, the diversity present in the type site is pronounced (Butler 1965: Figure 9 and 10). However, the speculation that the Haskett projectile point might have been used for killing Bison is enticing. Why would a Haskett point be found in a site dominated by waterfowl remains? Could it indicate a wide diet breadth within a generalized hunting pattern? There were bison in Harney Basin during the early Holocene, and their exploitation is likely. Butler suggested that the people who made Haskett were following the bison and grasslands into the High Lava Plains from the Intermontane areas extending from the Great Plains (Butler 1965:9).

I would add that there seems to be a correlation of Haskett with lake and marshlands as well, and continued use of the uplands is testified to in the presence of upland obsidian sources in the assemblage at the Weed Lake Ditch site. Another question arises about the two different types of Haskett points - does this presence indicate the exploitation of different game resources that require differing technologies? Beck and Jones propose a similar notion, that "lanceolate and/or square-based points and contracting-stemmed points are simply two technological forms performing different functions within the same toolkit. There is an evolving projectile technology—fluted/unfluted lanceolate/square-based and, perhaps, Haskett—and a thrusting-processing technology—Cougar Mountain, Parman, and possibly Lake Mohave…" (Beck and Jones 1997:204). However, I wonder which Haskett type they had in mind with this statement – would both of the types Butler identified fit into the same category? The presence of Haskett and both bison and waterfowl remains in the early occupation levels at Connley Caves may provide insight into this problem.

A pattern is emerging from sites containing projectile points similar to the Haskett type. In the Harney Basin and surrounding regions, these sites date to between 9,500 and 10,200 ^{14}C yrs BP, are associated with gravels laid down during the Late Pleistocene/Early Holocene lake highstands of the northern Great Basin and Snake River drainage (e.g. Redfish Overhang, Dirty Shame Rockshelter, possibly Headquarters site), and in some cases are associated with waterfowl remains (Weed Lake Ditch site, Connley Caves), and, in the Cougar Mountain and Connley Caves sites, bison. Further exploration of this apparent pattern needs to be undertaken to see if there are any technological or subsistence connections that may further shed light on the Haskett tradition.

Comparison with the Nials Site. The Nials site (35HA2828) is located approximately 1.5 miles (2.41 km) east of the Weed Lake Ditch site on the southern shore of Harney Lake. The site is an Early Holocene occupation complete with Great Basin Stemmed projectile points, two Crescents, and a large faunal assemblage. Bonstead (2000) proposes that the occupation of the site occurred around 8,000 ^{14}C yrs BP, although there are no direct dates.

Out of the 14,504 small bone fragments recovered from the Weed Lake Ditch site, only 560 specimens were identifiable to the family, genera, or species level. Of these, 176 were obviously intrusive bones (mostly vole and jackrabbit) being much lighter in color, and so are not included in the graphs and comparisons below. Of the 5,680 bone fragments recovered from the Nials site, 480 were identified to the family, genera, or species level (Bonstead 2000: Table 3). Although many of the same animals are found within the two assemblages, striking differences in the number of fish and waterfowl beg the question of whether these dissimilarities are due to either varying subsistence preferences or the season of occupation (Table 2.1). Both waterfowl hunting and fishing were practiced by the *Waada* Eaters in recent history during winter months (see Figure 5; Couture et al. 1986; Couture 1976), with fishing and rabbit drives being practiced slightly earlier (~ December) than intensive waterfowl use according to Figure 5 (Couture et al. 1986). However, both Weed Lake Ditch and the Nials sites may be winter occupations, so the differential presence of fish and waterfowl in them may be due to distinct subsistence strategies.

Table 3. Comparison of Faunal Assemblages from the Weed Lake Ditch and Nials Sites.

Animal Type	*Nials Site*	*Weed Lake Ditch Site*
Waterfowl	3%	78%
Fish	65%	3%
Rabbits, Hares, Pikas	21%	8%
Rodent	4%	3%
Terrestrial Birds	3%	2%
Herp	2.50%	3.50%
Artiodactyl	1%	0.50%
Canid	0.50%	1%
Unidiff. Mammal	-	1%
Total	100%	100%
* Total NISP for Nials Site = 480, Weed Lake Ditch Site = 384		

The lithic technology at the two sites is similar in that both have Stemmed projectile point types, Crescents, relatively large lithic debitage assemblages, and a similar distribution of material types. Eagle's nest chert, a nearby (< 3 miles) chert source makes up 86% of the 26,272 pieces of lithic debitage at the Nials site. The same material makes up 84% of the 16,242 pieces of lithic debitage at the Weed Lake Ditch site. Obsidian is the next most common material of both of the sites, with 7.4% at the Nials site and 12% at the Weed Lake Ditch site. Rhyodacite is found at both sites, and makes up 6.2% of the Nials site lithic assemblage and 2.5% of the Weed Lake Ditch site lithic assemblage. Numerous chert bifaces of various stages of reduction are also found at both sites.

Although these early Holocene sites have much in common, there are some important differences in the lithic assemblages. The temporally diagnostic projectile points at the Weed Lake Ditch site identified as Stemmed points (including Haskett) have basal lateral grinding, and some basal taper, but no distinct shouldering. The Stemmed projectile points identified at the Nials site have sharp angled shoulders near the base of the point with distinct necks. Therefore, these points are not of the Haskett tradition like those of the Weed Lake Ditch site. And, although there are a few untyped Stemmed points identified from the Weed Lake Ditch site (classified as such because of their fragmented nature), they do not resemble those identified as such at the Nials site.

In addition to the Stemmed projectile points, Bonstead (2000) identified a Black Rock Concave base preform from the excavation. Although concave base points were located during the surface survey near the Weed Lake Ditch site, none were found in the buried cultural material. The Crescents illustrated in Bonstead (2000) are not identified as to whether or not they came from the surface or buried component. However, they appear to have been prepared using a biface-reduction manufacture technique instead of a flake manufacture technique like the Crescent recovered at the Weed Lake Ditch site.

Obsidian source locations from the two sites also differ. The Nials site had 20 of its artifacts sourced using XRF analysis while 22 artifacts from the Weed Lake Ditch site were sourced. Both sites have Glass Buttes 3, Buck Spring, Venator, Big Stick, and Glass Buttes 6 obsidian present in their assemblages (China Lake is also reported from

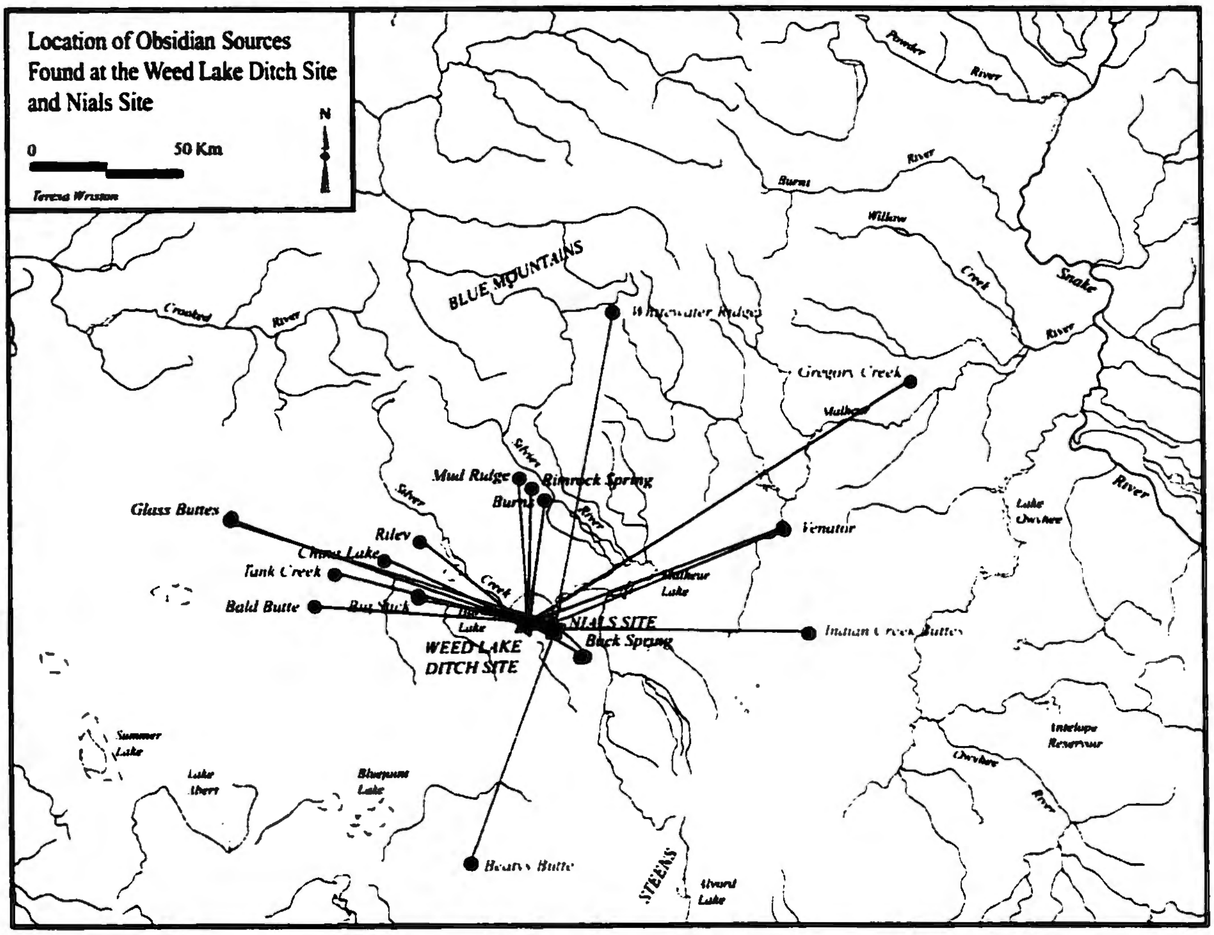


Figure 26. Obsidian and rhyodacite sources for the Weed Lake Ditch and Nials sites.

both, but at the Nials site the artifact sourced was from the surface and is not included in the comparison). However, obsidian from the Beaty's Butte, Indian Creek Buttes, and Whitewater Ridge obsidian sources has been found at the Nials site and not at the Weed Lake Ditch site. All of these sources are found to the south and east of the sites. The sources found at the Weed Lake Ditch site that are not found at the Nials site include: Gregory Creek, Rimrock Spring, China Lake, Burns, Mud Ridge, Bald Butte, and Tank Creek. The Venator source (a good source of rhyodacite that is found in both sites) and Gregory Creek (only found at the Weed Lake Ditch site) sources are found near the North

Fork of the Malheur River, and head of the Snake River Drainage - outside of the hydrographic Great Basin.

Unfortunately, the low number of sourced samples limits meaningful comparisons and interpretations of the obsidian source distributions for these sites. However, general trends are apparent. The assemblage from the Weed Lake Ditch site is composed of obsidian from north of the site, extending east and west along the margins of the basin, following major valleys and waterways (Figures 25 and 26). The Nials site seems to be in the center of the obsidian sources present in its assemblage (Figure 26). The number of different sources is also interesting. The Nials site had nine different sources for the 20 samples submitted, the majority of which were from either Beaty's Butte (n = 4) or Buck Spring (n = 8). The Weed Lake Ditch site had 12 different sources in the 22 samples submitted from the excavation, with the Glass Buttes 3 and 6 (n = 5) providing the most samples, followed by Gregory Creek (n = 4) – notice that these are on opposite sides of the basin (Figures 25 and 26). Of the 22 samples submitted from Weed Lake Ditch site, 12 were prepared tools, while the other 10 were flakes. No proximity/stage of reduction migration pattern emerges after plotting different stages of lithic reduction against sources; no travel direction can be ascertained. Flakes still occur from the farthest sources identified, along with advanced staged artifacts, suggesting that the people still carried bifaces large enough to produce flakes from sources far to the east (Gregory Creek) and to the west (Glass Buttes). However, a less complex pattern is apparent from the Nials site obsidian sources (Figure 26; Bonstead 2000: Appendix A, 107). The earliest stage artifacts are from the closest sources, whereas artifacts in a more advanced stage of reduction derive from more distant sources.

Jones et al. (2003) have suggested that the amount of extralocal lithic sources present in a lithic assemblage can reflect mobility patterns. Given the high number of sources and the stages of reduction present at the Weed Lake Ditch site, it is likely that people who created the sites were highly mobile foragers with low residence time. I think that the pattern at the Nials site reflects high mobility, but within a confined range - with the Harney Basin providing the center of resource exploitation. I am less sure about the Weed Lake Ditch site source pattern. No distinct lithic source pattern or travel direction can be determined, and, if the people were highly mobile foragers, they may have been temporary inhabitants with no fixed seasonal round or established territory.

One possible explanation for the different source patterns at the two sites is found in the ethnographic literature. "When resources become seasonally unavailable, mid-latitude hunter-gatherers must either store summer resources or locate their winter camps in one of the relatively few places where winter resources are available. Either way, as a result of the high transport costs of bulk, storable commodities (e.g. Barlow and Metcalfe 1996; K. Jones and Madsen 1989), they become tethered to a fixed location and are less likely to move from point to point across the landscape during the winter months" (Madsen 1999:79). Perhaps the people that inhabited the Nials site had begun to cache supplies for winter use in the lowlands, effectively tethering them to this location, a location that has the lowest elevation in the basin and reliable winter resources in the form of fish, waterfowl, and game. In contrast, the people that inhabited the Weed Lake Ditch site did not cache food for winter and maintained high residential mobility even in the cold season.

The comparisons of the Nials and Weed Lake Ditch site have produced some interesting but subtle differences that may warrant further investigation, including additional obsidian sourcing to see if the patterns of source distribution are maintained, and more detailed lithic analysis and comparison.

Comparison of the subsistence choices, projectile point technology, and obsidian source distribution between the Weed Lake Ditch site and the nearby early Holocene aged Nials site have shown distinct differences in otherwise similar assemblages. Since both of these sites would normally be lumped into the Stemmed tradition, this comparison serves as a reminder that different subsistence and foraging strategies were present over the broad timeline allowed for this lithic tradition.

Bone beads and Haskett. The recovery of a bone bead preform from the excavation provides a glimpse into Haskett culture, and the fact that stylistically similar bone beads are found at the Sentinel Gap Haskett site in Washington prompts the question of whether or not this is a cultural trait of Haskett people. Beads are beyond subsistence; they may function as "bodily ornamentation, currency, energy storage and transfer mechanisms, and symbols of social status" (Jenkins and Wimmers 1994:107; see also Binford 1972; King 1990). They may be an expression of cultural differences and similarities.

Whatever the intended use of the bead preform, its presence in an Early Holocene site requires an adjustment to the bead chronology so far established for the Harney Basin. Olivella shell beads dated to ca. 5,000 ^{14}C yrs BP were the oldest documented beads from the Harney Basin (Jenkins and Wimmers 1994) before the Weed Lake Ditch Project. Now we have a much older date to add to the Bead chronology of Jenkins and Wimmers – that of a single bone bead preform dated to 9,820 ^{14}C yrs BP.

New Date for the Last Highstand of Pluvial Lake Malheur. The Weed Lake Ditch project has also revealed information on the timing of the lake level fluctuations of pluvial Lake Malheur. The new early Holocene highstand date of ca. 9,860 ^{14}C yrs BP pushes back the previously established date by over 1,200 years. This date corresponds well with highstands occurring elsewhere in the Great Basin.

Researchers (Dugas and Bullock 1994; Dugas 1998) have proposed that at ca. 1,000 ^{14}C yrs BP a highstand of Malheur-Harney Lake may have reached the sill level at 4114 feet. However, no evidence was found of this late Holocene highstand during the Weed Lake Ditch Project. All evidence at the embayment containing the Weed Lake Ditch cut indicates that the last time the lake reached an elevation of ca. 4114 feet was at 9,860 ^{14}C yrs BP.

Data collected during other projects (Dugas 1996 and 1998; Musil 2002) suggest that relatively mesic conditions continued in Harney Basin after the end of the Younger Dryas ca. 10,000 ^{14}C yrs BP until around 7,300 ^{14}C yrs BP. These findings also have correlates in other parts of the Great Basin (Wigand and Rhode 2002).

Marsh Optimality in the Early Holocene. The fact that the Paulina Marsh, near Connelly Caves, was most productive between 10,000 and 7,000 ^{14}C yrs BP (Jenkins et al. 2000; Grayson 1979), after the recession of the large pluvial lakes began but before the lake receded to modern levels, is telling. Marsh productivity is dependent on water level. It must not be either too high or too low to maintain species diversity and richness (Fowler 1992). This has archaeological implications because, for perhaps the first time, the marsh as a resource may have become more inviting, more optimal, than large game to hunters and gatherers during the early Holocene. I believe the people that inhabited the Weed Lake Ditch site were most likely maintaining wide diet breadth and a generalized foraging pattern, based on the obsidian source distribution in the uplands, the projectile points (Haskett) found in the lithic tool assemblage, and the presence of leather, bison bones, and bone tools from the technologically affiliated earliest component of Cougar Mountain cave; but marshes may have become more important to subsistence during this time.

CHAPTER 8: CONCLUSION

The Weed Lake Ditch Project has provided a revised date for when the last highstand of Pluvial Lake Malheur occurred, and supplied evidence that people inhabited its shoreline during that highstand. In addition to establishing the stratigraphic chronology of the Weed Lake Ditch embayment, the site has offered details on subsistence in the form of faunal material, provided a minimum land-use area for its inhabitants through obsidian sourcing, and supplied a large lithic assemblage for future investigation. The Haskett projectile points found at the site serve to illustrate possible cultural and/or technological similarities to other sites in the region. The bone bead preform is the earliest known in the Harney Basin, and provides an exciting correlate to those found at Sentinel Gap in Washington.

Future Work. This project has provided abundant information on the inhabitants of the Weed Lake Ditch site's subsistence patterns, environmental setting, and geographic movements, but it has also served to outline research problems that should be addressed in the future. For instance, little excavation has been done above the 4114 ft sill elevation in the Harney Basin. If we are to find the earliest inhabitants of this area, we should look above the sill level for pockets of deposition. Transgressing and regressing wave action below the sill elevation would most likely relocate and/or destroy any archaeological sites older than ca. 9,860 ^{14}C yrs BP (Nials 2002:23). In addition, the shoreline features (gravel bars) located above the sill level should be further investigated for a more complete understanding of the geomorphic and lake level history in the Harney Basin when people first arrived.

We also need to perform statistically significant lithic source analysis and hydration for sites with dated contexts. The ability of sourcing to provide the minimum geographic area exploited by a group is a powerful tool for archaeological modeling, giving insight into resource use (uplands vs. lowlands), possible trade routes, and direction of travel. However, in order to be modeled in a statistically meaningful way, we need more of the obsidian sourced from the Weed Lake Ditch, Nials site, and other buried early Holocene assemblages that possess temporal control. This may help show the variations between different aged early Holocene assemblages while providing a baseline for comparison with undateable surface sites.

The morphological characteristics that differentiate Haskett, Cougar Mountain, Lake Mojave and other similar points, often described using the general term of Stemmed projectile points, need to be established and distributed to the archaeological community. A guide to identification and description would facilitate inter-and-intra basin comparisons of archaeological sites and establish whether or not there are temporally significant subcategories of the Stemmed tradition. For instance, in the High Lava Plains, Haskett points seem to date between 9,500 and 10,200 ^{14}C yrs BP, whereas the date range for them in the rest of the Great Basin is between ca. 7,240 and 11,200 ^{14}C yrs BP (Beck and Jones 1997: Table III).

The Weed Lake Ditch Project has provided information on how one group of people were living for a short time along the southern shore of Pluvial Lake Malheur. However, many questions remain as to their cultural affiliation, relationship to the land and whether they were ancestral to the later inhabitants of the Harney Basin.

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APPENDIX A: EXCAVATED MATERIALS

Table 4. Radiocarbon results from the Weed Lake Ditch Project

Lab Number	Analysis Type	Project Number	Specimen Number	Material	Sample Notes	Sample Location	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age	2 Sigma calibrated results (95% probability)
		35HA341	9-55	Charcoal	< 2 grams intermixed with sediment	Unit A (80-90 cmbd stratum 4)	"no separable charcoal component"			
		35HA341	20-31	Bone	32.4 gms, 649 longbone fragments	Unit B (80-90 cmbd stratum 4)	"Yielded only invasive organics and or very degraded collagen"			
Beta-160004	AMS	35HA341	35-21	Charcoal		Unit C (91cmbd stratum4)	105.0 ± 0.5 pMC	-23.4 o/oo	104.7 ± 0.5 pMC	
Beta-161511	AMS	35HA341	100-01	Shell	7.5 gms of *Vorticifex effuses*	BHT1	9540 ± 80 BP	-5.4 o/oo	9860±80 BP	(Cal BP 11540 to 11500) and (11350 to 11160)
Beta-172009	AMS	35HA341	2002-1	Shell	0.1 gm of *Gyralus parvus*	Sed. Sample - "Marsh" deposit	9230 ± 60 BP	-5.9 o/oo	9540 ± 60 BP	(Cal BP 11030) and (Cal BP 10980) and (CalBP 10750)
Beta-172010	AMS	35HA341	20-29	Shell	0.1 gm of *Lymnea*	Unit B (80-90 cmbd stratum 4)	9510 ± 60 BP	-6.1 o/oo	9820 ± 60 BP	(Cal BP 11280 to 11160)
Beta-172011	AMS	35HA341	2002-2	Shell	1.1 gms of *Fontelicella hendersoni*	Gravel Beach Bar	9210 ± 60 BP	-4.1 o/oo	9550 ± 60 BP	(Cal BP 11140 to 10670)

(Beta Analytic 2000, 2001, and 2002)

Table 6. Radiocarbon Dates from sites on the shores of Malheur and Harney Lakes

Lab #	Sample #	Content	Sample Type	Elevation (m)	Elevation (ft)	Site #	Conventional 14C Age (BP	2 sigma Cal. Intercept 1	2 sigma Cal. Intercept 2	Notes
Gehr (1980:170 & Field Notes) South shore of Harney Lake at Wood Lake Ditch Cut										
USGS-459A	35HA342-6	Lakeside of a gravel bar	Freshwater snails	1249 2	4098 43	35HA342	22,900 ± 260 BP			*Vorticifex effusus, Parapholyx or Pompholyx*
USGS-459B	35HA342-6	Lakeside of a gravel bar	Freshwater snails	1249 2	4098 43	35HA342	32,040 ± 400 BP			*Vorticifex effusus, Parapholyx or Pompholyx*
USGS-458	35HA342-7	underneath rusty gravel lense, above 840 & 841	Freshwater snails	1249 9	4100 72	35HA342	23,800 ± 500 BP			Technician "Fluff" core and rind Co2 not collected separately, so were combined (Gehr Personal Communication) *Vorticifex effusus, Parapholyx or Pompholoyx*
USGS-840	35HA342-62	15 cm above 841within gravels	Freshwater snails	c 1249 9	4100 72	35HA342	29,200 ± 300 BP			*V effusus, H newberri, F hendersoni*
USGS-841	35HA342-63	base of gravel bar	Freshwater snails	c 1249 7	4100 06	35HA342	29,700 ± 280 BP			*F hendersoni, V effusus, P ultramontanum*
USGS-460A	35HA342-8	Lense within Gravel Bar	Freshwater snails	1250 4	4102 36	35HA342	9260 ± 60 BP			*Lymnea* (submission form), *Fontelicella hendersoni* (thesis pg 168)
USGS-460B	35HA342-8	Lense within Gravel Bar	Freshwater snails	1250 4	4102 36	35HA342	9820 ± 50 BP			*Lymnea* (submission form), *Fontelicella hendersoni* (thesis pg 168)
USGS-461A	35HA342-9	Wavecut Terrace and Gravels	Freshwater snails	1254 4	4115 49	35HA342	8060 ± 50 BP			From auger hole either 5-10 cm below surface (thesis 168) or 10 to 15 cm below surface (submission form) *Lymnaeid* (submission form), *Fontelicella hendersoni* (Thesis 168)
USGS-461B	35HA342-9	Wavecut Terrace and Gravels	Freshwater snails	1254 4	4115 49	35HA342	8680 ± 55 BP			From auger hole either 5-10 cm below surface (thesis 168) or 10 to 15 cm below surface (submission form) *Lymnaeid* (submission form), *Fontelicella hendersoni* (Thesis 168)
Musil (2002) at Malheur National Wildlife Refuge Headquarters south of Malheur Lake										
Beta-160183	T1-1-A	Marsh Deposit (2b)	Soil Sample	-1250 75	-4103 5	35HA403	7200 ± 60 BP	8160 Cal BP	7930 Cal BP	Although lower in elevation, stratigraphically above last shoreline's gravels
Beta-160184	T1-1-B	Marsh Deposit (2b)	Soil Sample	-1250 75	-4103 5	35HA403	6920 ± 60 BP	7850 Cal BP	7650 Cal BP	Although lower in elevation, stratigraphically above last shoreline's gravels
Wriston (2003) within Wood Lake embayment south of Harney lake										
Beta-161511	35HA341 100-1	Shell bed ~2 5 ft below highstand in elevation, but stratigraphically synonymous (capped with then gravel lense) with Gravel Shoreline	Freshwater snails	-1253 25	-4111 72	35HA341	9860 ± 80 BP	11,540 to 11,500 Cal BP	11,350 to 11,160 Cal BP	*Vorticifex effuses* - nearly clear
Beta-180004	35HA341 35-21	Cultural stratum - 91 cmbd	Charcoal	-1252 42	-4109	35HA341	104 7 ± 0 5 pMC	modern	modern	root burn, thrown out
Beta-172009	35HA34120021	Marsh stratum found just above gravel bar on south side	Freshwater snail	-1252 0	-4107 61	35HA341	9540 ± 60 BP	11 130 Cal BP	10,660 Cal BP	*Gyralus parvus*
Beta-172010	35HA341 20-29	Cultural Stratum	Freshwater snail	-1252 42	-4109	35HA341	9820 ± 60 BP	11,280 Cal BP	11,160 Cal BP	*Lymnea* shell from excavation
Beta-172011	35HA34120022	Same location as Gehr's 35HA342-6	Freshwater snail	-1250 4	-4102 36	35HA341	9550 ± 60 BP	11 140 Cal BP	10 670 Cal BP	weathered *Fontelicella hendersoni*
Raven & Elston (1992) - Site 35HA1030 south of the Narrows Between Malheur and Harney Lake										
Beta-51527	A1-3-1 13	Unit 1 Surface stratum, well-developed soil	Freshwater snail	-1250	-4101 05	35HA1028	7760 ± 110 BP			
Beta-51531	A3-8-1 2469	Unit 2 Soil, loam	Freshwater snail	-1249 52	-4099 5	35HA1028	7370 ± 200 BP			
Beta-51529	A2-8-2 14	Unit 3 Developed soil atop lake deposits	Freshwater snail	-1249 35	-4098 92	35HA1028	8440 ± 90 BP			
Raven & Elston (1993) - Dune islands north of Narrows & Dugas 1996										
Beta-57833	35Ha2222-TA-1	Unit 13a-fluctuating wave-worked lacustrine environment	Charcoal	-1246	-4087 9	35HA2222	9290 ±150 BP			
Beta-57834	35Ha2222-TA-1	Unit 13a-fluctuating wave-worked lacustrine environment	Freshwater snail	-1246	-4087 9	35HA2222	9500 ± 210 BP			"Marsh-related species"
Beta-57830	35Ha1904-TA-2	soil - stratum 24-26	Freshwater snail	-1245 36	-4085 83	35HA1904	5040 ± 60 BP			
Beta-57831	35Ha1914-TA-1	Soil - Unit 2a	Charcoal	-1248	-4094 49	35HA1914	820 ± 100 BP			
Beta-57832	35HA1914-TA-2	Soil - Unit 2a	Sediment - Peat?	-1248	-4094 49	35HA1914	810 ± 70 BP			
Beta-58183	35HA1904-D1-	Hearth feature in D1	Charcoal	inferred	-4097 8	35HA1904	1050 ± 70 BP			surface hearth on adjacent site
Washington State University		Trench A, ~1 8 meters be within fine-grainedlake sediments	tephra	-1247 36	-4092 39	35HA1914	-70,000-80,000 years ago			TuleLake-64 (T-64)
Dugas et al. (1995) - Stubblefield Lookout Tower Site						35HA53				
Beta-78972	35HA53-A1-2-5	Feature 1 - hearth about 30 cmbs	Charcoal	inferred	-4126	35HA53	580 ± 50 BP	cal AD 1295	cal AD 1435	
Beta-78974	35HA53-A7-2-2	Feature 2- diffuse charcoal, hearth at surface	Charcoal	inferred	-4126	35HA53	130 ± 120 BP	cal AD 1655	cal AD 1950	
Beta-77124	35HA53-A4-6-4	Feature 4 - burial	Charcoal	inferred	-4126	35HA53	610 ± 40 BP	cal AD 1295	cal AD 1420	
Beta-78973	35HA53-A5-5-5	Feature 5 - hearth	Charcoal	inferred	-4126	35HA53	670 ± 60 BP	cal AD 1280	cal AD 1410	
Dugas & Bullock (1994) - Headquarters Site south of Malheur Lake						35HA403				
Beta-68628	A1-4-5 1	Midden beneath grove, stratum 3 Unit A1	Charcoal			35HA403	870 ± 80 BP			
Beta-68629	B1-4-5 1 and B	Unit B Bulk sample - stratum 3	Charcoal	-1253 91	-4112 82	35HA403	980 ± 100 BP			
Beta-68630	CO-O-14 2	hearth, stratum 16	Charcoal	-1254 14	-4114 63	35HA403	400 ± 50 BP			
Beta-68631	C1-7-1 1	stratum 20, unit c1 "underlies beach scarp & sediment (4113 77 ft)	Charcoal	-1253 52	-4112 60	35HA403	1040 ± 70 BP			
Beta-68632	C2-12-2 1	Cache pit?, feature 3, unit c2	Charcoal			35HA403	430 ± 60 BP			
Beta-68634	E1-2-3 1	Unit E1, charcoal lens, feature 4	Charcoal			35HA403	370 ± 70 BP			
Beta-67359	35HA403-C3-1	contact between strata 18 and 23	Charcoal	-1253 75	-4113 34	35HA403	4,760 ± 240 BP			
Beta-68359	35HA403-C0-0-	Bulk Soil sample trench B stratum 25	Paleosol/organics	-1252 82	-4110 30	35HA403	8070 ± 80 BP			
Washington Sta	35HA403-B1-2	Unit B 2a-interspersed in clay	tephra	-1254 22	-4113 84	35HA403	23400 BP			dating to 980 BP
Washington Sta	35HA403-VC2-	Unit C stratum 3	tephra			35HA403	7000 BP			Mazama Llo Rock (or Tule Lake T-64)

Table 6. Total number and type of artifacts found in each strata

Stratum	Bone	Charcoal	Shell	Bead	Projectile Pt.	Crescent	Biface	Uniface	Utilized Flakes	Cores	Debitage	Other	Sed. Sample	Totals	Percentage
1	323	13	18		1		1				840		1	1197	3.68%
2	284	3	6				1				939		4	1237	3.80%
3	960	5	62				5				2087		2	3121	9.59%
3/4	27		2								112			141	0.43%
4	9907	12	1138	1	6	1	22	7	6	8	9660	48	2	20818	63.96%
5	2982		256				3	1	1	3	2568	42	2	5858	18.00%
6	20										27		3	50	0.15%
6/7	1										1			2	0.01%
7												1		1	0.00%
8											7			7	0.02%
Unidentifiable	34		1								81			116	0.36%
Totals	14538	33	1483	1	7	1	32	8	7	11	16322	91	14	32548	100.00%
Percentage	44.67%	0.10%	4.56%	0.00%	0.02%	0.00%	0.10%	0.02%	0.02%	0.03%	50.15%	0.28%	0.04%	100.00%	

Table 7. Weed Lake Ditch site debitage analyses

Stratum #	Count	Material Type	Core	I	II	Core Red.	Biface Thin.	Pressure	Unknown	Shatter	Total	Percentage
1	7	Basalt	0	0	0	0	2	0	5	0	7	0.83%
1	693	CCS	0	10	10	5	161	79	410	18	693	82.50%
1	119	Obsidian	0	0	0	0	42	17	55	5	119	14.17%
1	21	Rhyodacite	0	0	1	0	6	4	8	2	21	2.50%
Total	**840**		**0**	**10**	**11**	**5**	**211**	**100**	**478**	**25**	**840**	**100.00%**
Percentage			**0%**	**1.19%**	**1.31%**	**0.60%**	**25.12%**	**11.90%**	**56.90%**	**2.98%**	**100.00%**	
2	18	Basalt	0	0	0	0	6	2	11	0	19	2.02%
2	758	CCS	0	33	41	8	220	39	400	16	757	80.62%
2	120	Obsidian	0	2	1	0	35	27	53	2	120	12.78%
2	41	Rhyodacite	0	2	0	0	16	0	21	2	41	4.37%
2	2	other	0	0	0	0	1	0	1	0	2	0.21%
Total	**939**		**0**	**37**	**42**	**8**	**278**	**68**	**486**	**20**	**939**	**100.00%**
Percentage			**0%**	**3.94%**	**4.47%**	**0.85%**	**29.61%**	**7.24%**	**51.76%**	**2.13%**	**100.00%**	
3	38	Basalt	0	0	1	0	12	0	24	0	37	1.77%
3	1724	CCS	0	33	51	16	424	180	932	89	1725	82.65%
3	244	Obsidian	0	1	0	3	70	33	126	11	244	11.69%
3	69	Rhyodacite	0	0	0	0	21	10	35	3	69	3.31%
3	6	other	0	0	0	0	0	0	6	0	6	0.29%
3	6	Welded tuff	0	0	0	0	2	0	3	1	6	0.29%
Total	**2087**		**0**	**34**	**52**	**19**	**529**	**223**	**1126**	**104**	**2087**	**100.00%**
Percentage			**0%**	**1.63%**	**2.49%**	**0.91%**	**25.35%**	**10.69%**	**53.95%**	**4.98%**	**100.00%**	
4	128	Basalt	0	0	2	0	31	14	81	0	128	1.31%
4	8358	CCS	7	116	180	48	1749	2237	3715	313	8358	85.52%
4	1068	Obsidian	1	6	7	2	302	246	457	48	1068	10.93%
4	213	Rhyodacite	0	4	0	0	72	42	86	9	213	2.18%
4	3	other	0	0	0	0	1	0	2	0	3	0.03%
4	3	Welded tuff	0	0	1	0	0	0	2	0	3	0.03%
Total	**9773**		**8**	**126**	**190**	**50**	**2155**	**2539**	**4343**	**370**	**9773**	**100.00%**
Percentage			**0%**	**1.29%**	**1.94%**	**0.51%**	**22.05%**	**25.98%**	**44.44%**	**3.79%**	**100.00%**	

Table 7. Weed Lake Ditch site debitage analyses

Table 7. Weed Lake Ditch site debitage analyses (continued)

Stratum #	Count	Material Type	Core	I	II	Core Red.	Biface Thin.	Pressure	Unknown	Shatter	Total	Percentage
5	11	Basalt	0	0	0	0	2	0	9	0	11	0.43%
5	2096	CCS	2	31	37	7	395	877	691	58	2096	81.62%
5	388	Obsidian	0	0	2	0	95	104	179	8	388	15.11%
5	73	Rhyodacite	0	0	0	0	12	33	26	2	73	2.84%
Total	**2568**		**2**	**31**	**39**	**7**	**504**	**1014**	**905**	**68**	**2568**	**100.00%**
Percentage			**0%**	**1.21%**	**1.52%**	**0.27%**	**19.63%**	**39.49%**	**35.24%**	**2.65%**	**100.00%**	
6	25	CCS	0	0	3	2	11	2	7	0	25	92.59%
6	2	Obsidian	0	0	0	0	1	0	1	0	2	7.41%
Total	**27**		**0**	**0**	**3**	**2**	**12**	**2**	**8**	**0**	**27**	**100.00%**
Percentage			**0%**	**0.00%**	**11.11%**	**7.41%**	**44.44%**	**7.41%**	**29.63%**	**0.00%**	**100.00%**	
7	1	CCS	0	0	0	0	1	0	0	0	1	100.00%
Total	**1**		**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**100.00%**
Percentage			**0%**	**0.00%**	**0.00%**	**0.00%**	**100.00%**	**0.00%**	**0.00%**	**0.00%**	**100.00%**	
8RB	1	Basalt	0	0	0	0	0	0	1	0	1	14.29%
8	4	CCS	0	0	0	0	4	0	0	0	4	57.14%
8RB	2	Obsidian	0	0	0	0	1	1	0	0	2	28.57%
Total	**7**		**0**	**0**	**0**	**0**	**5**	**1**	**1**	**0**	**7**	**100.00%**
Percentage			**0%**	**0.00%**	**0.00%**	**0.00%**	**71.43%**	**14.29%**	**14.29%**	**0.00%**	**100.00%**	
?	71	CCS	0	0	2	0	30	5	33	1	71	87.65%
?	8	Obsidian	0	0	0	0	3	1	3	1	8	9.88%
?	2	Rhyodacite	0	0	0	0	0	0	2	0	2	2.47%
Total	**81**		**0**	**0**	**2**	**0**	**33**	**6**	**38**	**2**	**81**	**100.00%**
Percentage			**0%**	**0.00%**	**2.47%**	**0.00%**	**40.74%**	**7.41%**	**46.91%**	**2.47%**	**100.00%**	

Table 8. Northwest Obsidian Lab XRF analysis results for the Weed Lake Ditch Project samples

Site #	Artifact #	Unit	Quad	Depth (cmbd)	UTM - mE	UTM - mN	Artifact Type	Collection Date	Source	Ground Distance
35.HA.341	9-1	A		84.75	328927	4781963	Haskett PPT	7/25/2000	Venator	51 miles, 1373 ft
35.HA.341	9-2	A		80.5	328927	4781963	Scraper	7/28/2000	Gregory Creek	88 miles, 3696 ft
35.HA.341	9-28	A		87	328927	4781963	Flake	7/30/2000	Glass Buttes 6	52 miles, 474 ft
35.HA.341	9-29	A	-	87	328927	4781963	Flake	7/30/2000	Rimrock Spring	30 miles, 4421 ft
35.HA.341	9-34	A		88	328927	4781963	Uniface	7/30/2000	Big Stick	26 miles, 302 ft
35.HA.341	9-36	A	-	82	328927	4781963	Biface Frag.	7/29/2000	China Lake	33 miles, 3940 ft
35.HA.341	9-37	A		84.25	328927	4781963	Uniface	7/29/2000	Glass Buttes 3	52 miles, 474 ft
35.HA.341	9-56	A		80-90	328927	4781963	Flake	7/28/2000	Rimrock Spring?	30 miles, 4421 ft
35.HA.341	21-27	B		90-100	328927	4781962	Flake	7/31/2000	Gregory Creek	88 miles, 3696 ft
35.HA.341	21-18	B	SE	90	328927	4781962	Biface Frag.	7/31/2000	Glass Buttes 6	52 miles, 474 ft
35.HA.341	34-12	C	SE	90	328927	4781961	Flake	7/27/2001	Gregory Creek	88 miles, 3696 ft
35.HA.341	35-9	C	NE	95.5	328927	4781961	Uniface	7/24/2001	Burns	28 miles, 3506 ft
35.HA.341	51-35	D	NE	88-89.5	328928	4781963	Flake	8/8/2001	Buck Spring	51 miles, 4947 ft
35.HA.341	51-68	D	SE	85-90	328928	4781963	Stage V Biface	8/7/2001	Mud Ridge	38 miles, 250 ft
35.HA.341	52-5	D	NW	96	328928	4781963	Flake	8/11/2001	Rimrock Spring	30 miles, 4421 ft
35.HA.341	67-14	E	SE	91	328928	4781962	Flake	8/12/2001	Burns	28 miles, 3506 ft
35.HA.341	68-4	E	SW	97	328928	4781962	Flake	8/13/2001	Rimrock Spring	30 miles, 4421 ft
35.HA.341	68-5	E	SE	98	328928	4781962	Flake	8/13/2001	Glass Buttes 3	52 miles, 474 ft
35.HA.341 .	68-27	E	NW	95-100	328928	4781962	Stem base	8/13/2001	Glass Buttes 6	52 miles, 474 ft
35.HA.341	68-28	E	SW	100	328928	4781962	Biface Frag.	8/13/2001	Bald Butte	40 miles, 2947 ft
35.HA.341	68-33	E	NE	96	328928	4781962	Flake	8/14/2001	Gregory Creek	88 miles, 3696 ft
35.HA.341	80-2	F	NE	99-100	328928	4781961	Uniface	8/14/2001	Tank Creek	40 miles, 2059 ft
35.HA.341	60	N/A	-	?	~328950	~4782016	Stem PPT	1979	Glass Buttes 3	52 miles, 474 ft
35.HA.2827	2-40	N/A		surface	327450	4782344	Side-Notched PPT	7/21/1997	Tank Creek	40 miles, 2059 ft
Isolate	5131	N/A		surface	330620	4781414	Stem fragment	7/7/2002	Glass Buttes 4	52 miles, 474 ft
Isolate	5013	N/A		surface	327536	4782238	Stem base	7/11/2001	Riley	30 miles, 93 ft
Isolate	100-2	BHT1		130 cmbs	329161	4782719	Retouched Flake	8/20/2001	China Lake	33 miles, 3940 ft

Includes both Excavation and Surface Survey Specimens - Specimens not Excavated from Site are Highlighted

*** All UTMs in zone 11**

(Skinner 2002)

Table 9. Generalized faunal identifications from the Weed Lake Ditch Site (extrapolated from Livingston 2003)

Identification	Taxon	NISP	Subtotal	Total Type	Total Identified
Coot	American Coot	86			
Coot	undifferentiated	125			
Coot	*subtotal*		*211*		
Grebe	Western Grebe	25			
Grebe	undifferentiated	37			
Grebe	*subtotal*		*62*		
Duck	large	9			
Duck	medium	8			
Duck	*subtotal*		*17*		
Goose	undifferentiated	7			
Goose	*subtotal*		*7*		
Rail	small-size	1			
Rail	*subtotal*		*1*		
	Wetland Birds			**298**	
Bird	undifferentiated	7			
	Bird	**undifferentiatied**		**7**	
Artiodactyl	*undifferentiated*		*2*		
	Artiodactyl			**2**	
Rodent	*Squirrel*		*1*		
Rodent	*Mice, Rats, Lemmings, Voles*		*1*		
Rodent	*Gopher/Woodrat*		*2*		
Rodent	*Muskrat*		*2*		
Rodent	*pocket gopher*		*1*		
Rodent	*vole*		*5*		
	Rodents			**12**	
Rabbits, Hares, Pikas	*lagomorphs*		*16*		
Rabbits, Hares, Pikas	*leporids*		*2*		
Rabbits, Hares, Pikas	*lepus*		*8*		
Rabbits, Hares, Pikas	*pygmy rabbit or cottontail*		*4*		
	Rabbits, Hares, Pikas			**30**	
Canid	*Dog,Wolf, Coyote*		*4*		
	Canid			**4**	
Mammal	*small-size*		*2*		
Mammal	*medium-size*		*2*		
Mammal	*large-size*		*1*		
	Mammals	**undifferentiated**		**5**	
Fish	*undifferentiated*		*12*		
	Fish			**12**	
Herp	*undifferentiated*		*1*		
Herp	*frog/toad*		*1*		
Herp	*lizard*		*12*		
	Herp			**14**	
		Total Identified			***384***

* Table does not include the185 obviously intrusive specimens identified (mostly voles and jackrabbit).

Table 10. Identified gastropod shell from the Weed Lake Ditch site excavation

Artifact #	CMBD	Stratum	Unit	Count	*Genus*	*species*	Preferred Environment
75-16	70	3	F	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
8-5	78.5	4	A	1	*Planorbella*	*subcrenata*	Marshes; perhaps partly but not wholly drying
9-46	82	4	A	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
9-47	80-90	4	A	1	*Vorticifex*	*effusa*	Perennial, oxygenated water: lake, creek, large spring
20-15	70-80	4	B	1	*Planorbella*	*subcrenata*	Marshes; perhaps partly but not wholly drying
20-29	80-90	4	B	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
20-29	80-90	4	B	1	*Planorbella*	*subcrenata*	Marshes; perhaps partly but not wholly drying
21-25	90-100	4	B	1	*Fonticella*	*hendersoni*	Perennial, oxygenated water: lake, creek, large spring
21-25	90-100	4	B	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
33-6	80-85	4	C	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
51-96	85-90	4	D	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
52-19	90-95	4	D	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
53-18	95-100	4	D	6	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
53-22	95-100	4	D	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
53-27	95-100	4	D	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
53-27	95-100	4	D	1	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
53-27	95-100	4	D	1	*Fonticella*	*hendersoni*	Perennial, oxygenated water: lake, creek, large spring
53-30	95-100	4	D	3	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-21	100-110	4	D	3	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-30	100-110	4	D	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
67-22	91	4	E	1	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
75-33	75-80	4	F	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
76-28	75-80	4	F	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-29	80-85	4	F	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-36	80-85	4	F	2	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-41	80-85	4	F	7	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-41	80-85	4	F	2	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
77-45	80-85	4	F	3	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-45	80-85	4	F	4	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
77-45	80-85	4	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
77-47	80-85	4	F	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-47	80-85	4	F	2	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
77-48	82.5-85	4	F	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
77-48	82.5-85	4	F	1	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
78-35	85-90	4	F	7	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
78-35	85-90	4	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying

Table 10. Identified gastropod shell from the Weed Lake Ditch site excavation

Artifact #	CMBD	Stratum	Unit	Count	*Genus*	*species*	Preferred Environment
78-38	85-90	4	F	9	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
78-38	85-90	4	F	10	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
78-43	85-90	4	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
78-43	85-90	4	F	2	*Planorbella*	*subcrenata?*	Marshes; perhaps partly but not wholly drying
78-43	85-90	4	F	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
78-48	85-90	4	F	4	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
78-48	85-90	4	F	6	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
79-12	90-95	4	F	1	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
79-12	90-95	4	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
79-16	90-95	4	F	8	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
79-16	90-95	4	F	1	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
79-16	90-95	4	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
79-17	90-96	4	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
79-17	90-96	4	F	3	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
79-17	90-96	4	F	17	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
79-23	90-95	4	F	5	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
79-23	90-95	4	F	13	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
79-26	90-95	4	F	6	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-34	100-110	5	D	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-27	100-110	5	D	5	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-27	100-110	5	D	1	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
54-7	100-110	5	D	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-13	100-110	5	D	1	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
54-14	100-110	5	D	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
80-12	95-100	5	F	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
80-12	95-100	5	F	2	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
80-14	95-100	5	F	1	*Lymnea*		Marshes; perhaps partly but not wholly drying
80-18	95-100	5	F	2	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
80-20	95-100	5	F	17	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
80-20	95-100	5	F	2	*Valvata*	*humeralis*	Marshes; perhaps partly but not wholly drying
80-25	95-100	5	F	4	*Gyralus*	*parvus*	Marshes; perhaps partly but not wholly drying
80-25	95-100	5	F	1	*Fonticella*	*hendersoni?*	Perennial, oxygenated water: lake, creek, large spring
		Total Identified		**212**			

* Preferred environmental conditions of each species from Gehr (1980)

APPENDIX B: STRATIGRAPHY

The Weed Lake Ditch site strata descriptions extrapolated from Nials (2000)

Stratum 1

Sediments in this stratum consist of fine to medium aeolian loamy sand. These deposits contain abundant partially- and totally-decomposed organic materials, which impart a distinctly darker color than observed in strata below. The surface of this stratum is irregular because of minor coppice accumulations around greasewood clumps present at the time of the ditch excavation. The sediments also contain abundant partially decomposed roots. The sediments have been mildly disturbed by compaction and loading during ditch excavation. Some gravels are present, and some pebbles appear to have been intruded downward into this stratum as a result of the construction process. Some gravels, however, appear to have been naturally present, probably as a result of erosion of nearby gravelly lacustrine bar deposits. As noted, the majority of sediments within the stratum were deposited by aeolian processes.

Stratum 2

These deposits (figure 6) consist of silty fine sand, deposited primarily by aeolian and localized sheetwash processes. The sediments display a very thin platy structure, and very fine vesicles are present throughout. The sediments are soft and disaggregate easily, first into very weak, very fine subangular blocky peds, and then into single-grain structure. Some of the platy structure may be the product of compaction from the historic surface, but most appears to be of pedogenic origin. When exposed in plan view, desiccation cracks are prominently developed, especially in the northern meter of the excavation unit. A small localized depression appears to have been located in this area during the time of deposition, in which very localized runoff deposited silt and fine sand in briefly-standing water. These sediments grade into slightly coarser fine sandy aeolian deposits in the southern portion of the excavation, that appear to have been minor sand dune or coppice accumulations. These sediments appear to have been the source for the sediments deposited in the depression described above. In addition to desiccation fractures, a 2 cm- to 4 cm-wide tension crack parallels the ditch face, and sediments have moved downward in both desiccation and tension fractures. Occasional artifacts were observed in these deposits during excavation. The artifacts were probably derived from an Archaic site at and near the pre-ditch surface in the general area of the excavation. These artifacts appear to have been transported to their present position either by a rodent activity or by movement along desiccation fractures.

Stratum 3

This stratum is composed of medium sand, deposited primarily by aeolian processes (figure 6). The sediments appear to have been derived from a relatively bare beach and recently-exposed littoral surface in immediately adjacent areas. The deposit has been somewhat affected by bioturbation and pedogenesis. The deposit appears to thicken slightly to the south, perhaps indicating minor erosion in the northern part of the profile area, although no distinct erosional surface was recognized. Weak soil formation has occurred from the surface of this unit, recognized by a very slight hardening of consistence and slight darkening of color in comparison to Stratum 2, above. Carbonates leached from sediments above are present, but there is also evidence of carbonate leaching from the surface of Stratum 3. Although the sediments are distinctly different in character in this locality, this stratum is believed to correspond to the "saltgrass/greasewood meadow" deposits associated with a later occupation of the nearby Biting Fly Site.

Stratum 4

Stratum 4 deposits (figure 6) consist of mixed gravel and medium-sand sediments. The gravel primarily consists of moderately well-rounded and sub-rounded discoid-shaped welded tuff clasts characteristic of beach bars in the area. Individual stones are randomly oriented, are contained within a sandy matrix, and comprise approximately 30 to 40 percent of the bulk of this deposit. The orientation and texture of the clasts indicate that bioturbation has modified the primary depositional integrity of the deposits. Few, however, show angular edges or disassociated angular fragments, suggesting that burial probably occurred relatively soon after initial deposition, before the fragments could be broken by frost action or by salt crystallization associated with frequent wetting and drying. Most of the clasts and artifacts contained within this stratum show a thin, discontinuous carbonate coating on bottom sides. I believe that this stratum originally was similar in nature to Stratum 6 below, and probably was deposited by temporarily higher waters associated with a brief rise in lake level, or perhaps by a storm surge that eroded bar deposits located lakeward of the site area.

Occupation of the site appears to have occurred early in the process of deposition of the stratum, and prior to pedogenesis. The area of excavation appears to have been near an activity area, as an unusually large number of flaked tools and bone fragments were recovered from a small area of excavation. Among the artifacts recovered was an almost complete, large, lanceolate-shaped, basally-ground projectile point formed on a very fine-grained, opaque, matte-luster volcanic rock containing small white phenocrysts. The material was tentatively identified in the field as rhyodacite, but laboratory examination has yet to occur.

Although the occupation appears to have occurred subsequent to the deposition of this stratum, numerous artifacts, including the aforementioned projectile point, are located within this deposit. The artifacts appear to have arrived at their present positions through downward movement associated with bioturbational processes. Tabular artifacts display random orientations, also apparently the result of post-occupation bioturbation. This contention appears to be supported by the observation that artifact size generally diminishes with depth in Strata 4 and 5.

Stratum 5

These deposits (figure 6) consist primarily of medium sand deposited primarily by wind. These sediments are interpreted to be redeposited beach and near-shore littoral sands derived from nearby, and that were exposed shortly prior to deposition. The structure is massive, and no primary depositional structures were observed. Sediments display a slightly hard to soft dry consistence, and are very friable when moist. Numerous krotavinas were observed, including several large ones still open at the time of excavation. Stones derived from Stratum 4 were occasionally present throughout this deposit, but were more frequent in the upper half. Several flakes were observed in the ditch wall prior to excavation, concentrated in the upper few centimeters of this stratum. The artifacts appear to have been moved to that position by turbation processes. Excavation showed that the limited number of artifacts in this stratum were distinctly smaller than in above strata, and most appeared to be related to rodent disturbance.

Stratum 6

This stratum (figure 6) consist of a thin bed of discoidal, occasionally clast-supported gravels deposited very rapidly in either a beach/bar environment or derived from a similar nearby deposit. Individual clasts are overlapping, and only minor amounts of coarse interstitial sand were present. A portion of this stratum (see Nials 2000) has been disturbed and does not show the primary depositional structure seen elsewhere in the profile. The gravels were rapidly deposited and covered, and show no evidence of bioturbation or pedogenesis. Discontinuous carbonate coatings are present on clasts, mainly on undersides. Although occasional pebbles are split *in situ*, very few disassociated angular fragments were found. It is possible that these deposits represent either a brief rise in lake level or are the product of erosion of lakeward bar deposits by a storm surge.

A single chert flake was observed within this stratum in the ditch sidewall. The flake was clearly in place, clearly of human manufacture, and displayed crisp, sharp edges, suggesting very limited transport within the beach/storm surge environment. The flake was over- and underlain by discoidal clasts displaying primary depositional orientations, and there appears to be no possibility of redeposition. Although not in a primary occupational context, the flake is significant, because it was deposited with the gravels, indicating that people were occupying the nearby environment prior to or at the time of deposition, i.e., on an existing lake edge. This fact, coupled with the rapid subsequent deposition of Strata 6, 5, and 4 supports the contention that people occupied an active lake margin in the immediate area.

Stratum 7

Stratum 7 (figure 6) consists of relatively soft medium sands that disaggregate easily to single-grain consistence. Extensive krotavinas are present within this deposit. Most of the sediments within this stratum display massive structure, but weak bedding is occasionally present, particularly in the southern end of the profiled area. Carbonate derived from weathering of younger strata is present in root pores, and locally discolors the sediments. When wetted, the color is distinctly greener than Stratum 5, although the two are of similar origin. My interpretation of these sediments is that they are primarily aeolian, derived from existing nearby beaches and bars, and locally re-worked by minor overland wash. The greenish color may be the product of reduction processes associated with an elevated water table. These sands appear to have been deposited quite rapidly during a period of temporarily lowered lake level or diminished storm magnitudes.

Although people should have been on the nearby landscape at the time of deposition (see Stratum 6 description), no artifacts were observed in the ditch wall, or recovered during excavation.

Strata 8, 9,and 10

This thick set of bar/beach deposit gravels (figure 6) could have been still further subdivided, but for our purposes, there seemed to be no point in extensive subdivision. The crest of this bar is located only a few meters south of the excavation area. These gravels formed during the 4,118 ft. lake highstand of Gehr (1980; Fig. 3), and thus are ostensibly about 8,680 radiocarbon years old (see *chronology* section).

Individual clasts display typical beach morphologies and locally show imbricate texture. Occasional variations in texture and lenses of finer-grained sediments reflect variations in wave energy and/or water depth. Boundaries between Strata 8, 9, and 10 are examples of such features. The uppermost portions of Strata 9 and 10 (Fig. 3) are lower-energy deposits that have distinctly finer clast size and contain numerous very well-rounded pumice nodules ranging from several millimeters to more than 1 cm in diameter. Strata 9 and 10 rise steeply to the south, and neither stratum contains as much sand matrix as Stratum 8.

Stratum 11

Sediments of this stratum (figure 6) consist of light-colored (almost white when dry) clay-rich silt deposited in subaqueous environments of a pre-9,200 BP version of pluvial Lake Malheur. The deposits are relatively resistant to erosion and generally form a short slope near the bottom of the ditch that is mantled by sediments eroded from the wall above. Stratum 11 is generally not visible in the area of the site, but where exposed by natural erosion or by digging, the upper surface is smooth, very abrupt, and erosional. No fossils were observed in this stratum, nor were any other materials suitable for dating. It is recommended that samples be collected for ostracode analysis in future studies.