Late Pleistocene / Early Holocene Archaeobotanical Study of Paisley Caves: Seeds as Diagnostic Environmental and Human Activity Markers

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Introduction

The Summer Lake Basin in Central Oregon has a long, complex history of human habitation. For millennia the resources of this dry region sustained hunters and gatherers who were able to adapt to long and short term climatic shifts. Changes in climate ecology are pronounced in this region of Oregon but have varied greatly even within the span of a decade (Aikens and Jenkins, 1994, p 564). At the end of the Pleistocene, the Summer Lake Basin saw the recession of pluvial Lake Chewaucan, eventually leaving brackish Summer Lake and Lake Abert (Fig. 1). During the period of Lake Chewaucan's recession, Summer Lake Basin was a highly productive area sustaining marshes and grassy environments, with forests skirting the higher reaches of the Basin.

This highly productive region would have been attractive to hunter-gatherer people settling in the area in the late Pleistocene. To this day, the region remains fairly productive, although this productivity is limited primarily to riparian environments around the Ana River, the Chewaucan River, upper and lower Chewaucan Marsh between Summer and Albert lakes, and in the lower mountain reaches of the Chewaucan River where fish and shellfish remain fairly plentiful.

This archaeobotanical study focuses on macrobotanical materials excavated at Five Mile Point Butte, also called Paisley Caves, from strata deposits containing anthropogenic materials dating back at least 14,300 years (Jenkins et al., 2004, p 7-9). These macrobotanicals were gathered over two summer field sessions in 2009. The aim was to test whether the macrobotanical assemblage from the caves would show evidence of dramatic climate shifts at the end of the Pleistocene and into the early Holocene, as well as to add to the growing body of evidence of early human occupation in the caves.

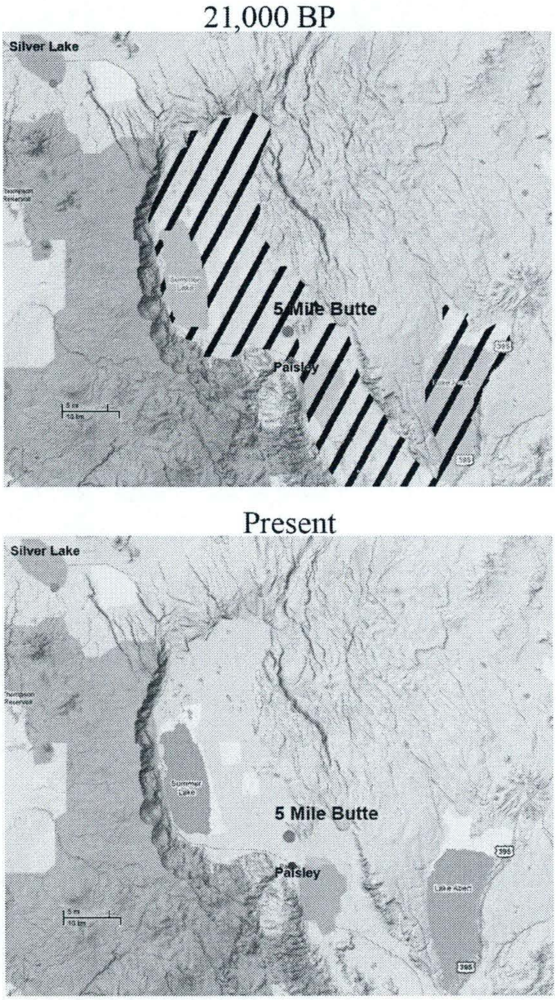

Figure 1 Lake Chewaucan (indicated by diagonal bars) circa 21cal.BP and Summer Lake Basin today (http://maps.google.com/).

It may be possible to detect changes in environmental conditions at the end of the Pleistocene through an evaluation of the botanical assemblage found at Paisley. Additionally, if humans were consuming seeds while at Paisley, their selection of seeds would likely also reflect a changing environment. My prediction was that the seeds will show patterns of both climate change and human responses to these changes.

The target time span for this project was the Late Pleistocene through the Early Holocene (Fig. 2). Arid conditions that foster the extraordinary preservation of plant materials make Paisley Caves attractive for archaeobotanical study. Although sediments have been disturbed in some areas by looters, animals, or other natural bioturbation, there are also many areas with high stratigraphic integrity. All the materials, however, are covered to some degree in wood rat urine and fecal matter.

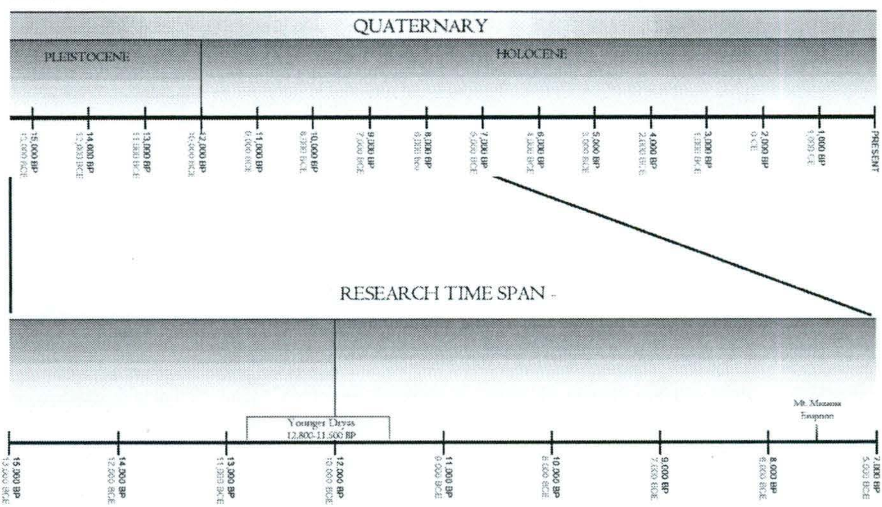

Figure 2: Research time span.

Botanical materials were recovered in association with dated cultural materials such as coprolites, cordage, and obsidian artifacts. Absolute stratigraphic dates were obtained through radiocarbon testing of material from the same units and excavation levels and provided the framework by which obsidian hydration dating was obtained. While every five-centimeter level was not radio carbon dated, the extensive amount of dating conducted at the site—146 radiocarbon dates and roughly 300 obsidian hydration measurements—provides for a unique degree of confidence in the probable age of most seeds used in this study.

Reliable identification of plant materials was a crucial part of this study. While positive identification of some species remains undetermined, the family and genus of these specimens were identified and are included in the list with those determined more positively. With some notable exceptions, few archaeobotanical-specific studies have focused on Central Oregon, and none in the Summer Lake Basin specific to the Late Pleistocene. Some related studies have focused on the Fort Rock Basin (Aikens and Jenkins, 1994, pp 531-559), but those were studies of lowland Carlon Village and upland Boulder Village during a more recent period. This study extends further back in time but draws heavily from these previous studies and research structures. The general time span the samples in this study represent is from two thousand years before the Younger Dryas cold period up to the explosion of Mount Mazama 7,600 cal. BP. The most significant differences between the studies were the type of archaeological context from which the Paisley macrobotanicals were excavated as well as the enormous antiquity of the materials. In previous studies of nearby sites, the oldest samples dated from approximately 10,000 years ago. This highlights the significance of these caves for more intensive archaeobotanical study, especially as botanical remains are too often overlooked in favor of faunal and lithic remains (Lepofsky et al., 2001, pp 48-59). During excavations at Paisley, Dr. Dennis Jenkins emphasizes gathering and sorting as much archaeological material as possible. His foresight coupled with the information gathered from other cave materials may clear some of the haze looking back over 14,000 years.

Climate Changes, Geologic Setting & Cave Morphology

The end of the Pleistocene was a cold, dry period emerging from the last Glacial Maximum centered about 19,000-18,500 BCE (Ubelaker et al., 2007, p 48). The terminus of the Pleistocene was marked by a dramatic drop in northern temperatures that deeply affected the northern hemisphere, particularly North America, but had relatively little impact on the southern hemisphere (Kaplan et al., 2010). This dramatic drop, called the Younger Dryas, coincided with a period that saw the end of all megafauna in North America (Fig. 3).

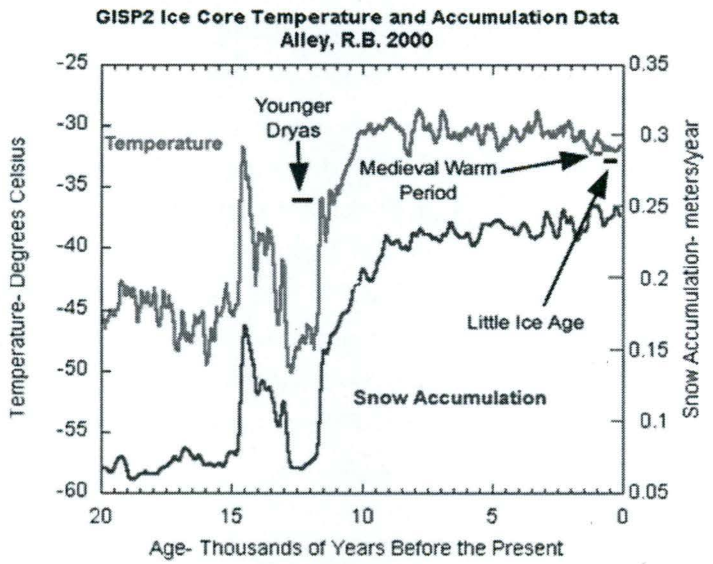

Figure 3: Temperature variations at the end of the Pleistocene into the Holocene (Alley, January 2000). Image used with permission.

The Northern Great Basin, where Paisley Caves are located, is a geologically unique region. Arid as a result of the rain-shadow effect created by the High Cascades, the Northern Great Basin is bordered by the Columbia Plateau region to the north and narrowly to the west, where an arm of the Plateau is wedged between the High Cascades and the Great Basin in the Deschutes Valley. The flora of today's Northern Great Basin shows more in common with Plateau biodiversity than with the rest of the Great Basin. The overall Great Basin itself is unified more by geologic standards than by homogenous environmental ones. This unifying geologic setting consists of endorheic drainage systems that do not drain to the ocean. The Southern Great basin is primarily desert and greatly drier than in the northern areas. Evidence for the types of plant materials present in the Northern Great Basin at the end of the Pleistocene comes primarily from pluvial lake core samples (Mehringer, 1986).

The High Cascades were heavily glaciated during the Pleistocene, and glaciers were present in the Steens Mountains east of the Paisley region. Polar conditions were present farther north caused by the Cordilleran Ice Sheet extending south into central Washington. What effect the climatic conditions of this ice sheet 400 to 500 miles north of Paisley had on the region is unclear. It seems likely that the ice sheet created conditions that probably kept the Paisley region cool year round.

Relative to the change from Pleistocene cool and dry to Holocene warm and dry, the seed assemblage from Paisley probably reflects more of a vertical shift in flora in response to climatic changes at the end of the Pleistocene than lateral, region wide shifts. In other words, the same seeds seen in 14,000-year-old deposits are still seen in the Paisley Caves region although some species may have shifted to higher elevations.

Understanding the geology of Five-Mile Point Butte is key to understanding its archaeobotanical assemblage and early human interaction with the caves. The butte is made of loosely consolidated rhyolitic scoria (Jenkins, 2010). At the peak of the Pleistocene, wave action in Lake Chewaucan carved eight west-facing caves into the butte. The caves are at an elevation of 4,520 ft (1,377.696 m), approximately 120 feet/36.58 meters above the lake floor. A talus base of boulders extends out from the butte and is composed of loosely consolidated scoracious basalt breccia that has broken off over time because of erosion and seismic activity (Fig. 4). The weakly consolidated stone is subject to fault breakage. For instance, the front overhang that made Cave 2 a true cave collapsed approximately 2,000 years before present, turning Cave 2 into a rock shelter rather than a true dark cave. The depth of caves may offer clues to the kinds of botanicals and faunal remains that may be predicted deeper inside. Moreover, changes in cave morphology can also have a dramatic effect on material preservation and sediment deposition.

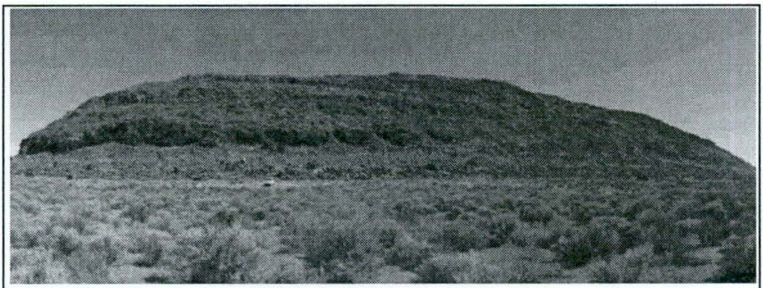

Figure 4: Five-Mile Point Butte. Caves are clearly visible with Cave 1 the cave furthest right and Cave 8 furthest left.

Pluvial Lake Chewaucan experienced multiple water level expansions and regressions during the late Pleistocene, finally continuing to fall to current levels throughout the Holocene. Combined studies from Lakes Chewaucan and Fort Rock Lake show that the highest level occurred at 19200 BCE, after which a drop occurred with a second, lower high level around 11800 BCE (Ubelaker et al., 2007, p 57). When the caves first dried out enough for human habitation is unclear.

Even after the Caves did dry out, they were never used for long-term settlement by the early people of the Northern Great Basin. This is evident by the lack of material culture or behavioral pattern clues indicative of long-term settlement (i.e. deep hearths). It is likely the Caves went long periods without seeing any human habitation.

Methodology

The macrobotanical remains used in this study were recovered from Paisley Caves 2 and 5 during the National Science Foundation (NSF) excavation of 2009 and the Field School excavation of the same year. In both the NSF and field school sessions, excavation materials were collected from 1x1 meter units excavated by 5cm levels. Materials not found *in situ* or in the original location of deposition were collected from soil sifted through screens, which were 0.125 ($1/8^{th}$) inch gauge steel mesh and ideal for collecting smaller materials such as seeds and insects.

Artifacts, animal remains, botanicals, insects, ecofacts, and lithics were all collected in separate small bags, labeled, and placed into larger "day bags" for counting and cataloging in the lab. Soil samples were taken at the start of every level, and especially taken with the discovery of *in situ* coprolites. The coprolites and their subsequent soil samples were collected using a strict field protocol that protected the samples from as much modern contamination as possible (Jenkins, 2009). Soil samples taken from coprolite protected soil will allow an excellent opportunity for identification of microbotanical materials at a later date.

Selection of the botanicals to study was limited to samples recovered from the oldest strata possible. Once the most promising units were identified from catalog sheets, manual separation of seeds and certain other macrobotanicals commenced.

Physical collection meant removal of seeds from field collection bags. Examination by the naked eye was usually sufficient for initial selection, but a 10X stereomicroscope helped with the selection of seeds and the separation of non-seed materials such as scorpion stingers. After separation, all matching seeds were placed into acid-free gel vitamin capsules that do not degrade the seeds over time. Catalog numbers, which include accession number, project initials, cave, unit, level, catalog number, and, finally, the sub-catalog number assigned for this project were written onto each capsule along with MNI (minimum number of individuals), date and my initials. No flotation sequence was done at this time. The gel capsules were then placed into small acid free bags with the same information found on capsules but with the addition of a number assigned to individual bags from each unit. This number corresponded with the same number on the initial record sheet, which made finding a particular sample among many much faster.

After recording and separating the seeds, identifying them was the next step. A chart with columns for unit, levels, genus and species, MNI, levels and corresponding dates, weights, charred/non charred, and other characteristics helped maintain records of the pertinent information. In addition to the 10X stereomicroscope used for identifying seeds, a digital Celestron 20X microscope made it possible to hyper-enlarge and photograph sample seeds.

After cleaning up the images using Adobe Photoshop, the images were labeled and organized into page layouts. Figure 5 shows one of the results of this portion of the project. Much of the recorded data was not used in this portion of the analysis, but was saved and may provide critical information for later research. All data was entered into Excel for chart analysis.

Several sources provided important information for identifying

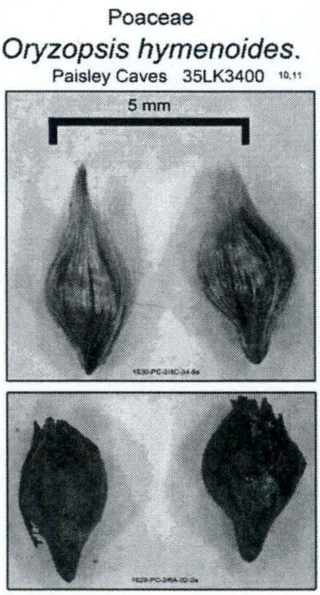

Figure 5 *Oryzopsis hymenoides* (Indian Rice Grass)

seeds. Those sources included books on weed seeds; seeds from the Plains, Wallowa Mountains, and the Columbia Plateau; and the University of Oregon archaeological papers identifying botanicals in the Fort Rock Basin. Some websites with images were valuable identification references. Most useful were the USDA Agricultural Research Service[1] and the Bend Seed Project.[2]

Analysis

Total seeds and species identified are listed in Table 5 in the Appendix. Table 1 shows the combined total seeds per cave. Although the time spans do not overlap except during the Younger Dryas, it is clear that there was a dramatic fall in overall seeds during the project's time-span. This may be indicative of a change in climate patterns affecting the local flora, or, if the seeds were primarily food seeds, then a change in human response and adaptation to changed food resources. To test the strength of that claim, I removed all seeds except two enthnographically important food seeds: *Ceanothus integerrimus* and *Oryzopsis hymenoides*.

Table 2 shows that in Cave 2, *Oryzopsis* is dominantly represented with a small showing of *Ceanothus*. This may a result of the proximity of *Oryzopsis* on the butte's talus slope and either rodent or wind deposition of seeds inside the cave. However, considering the artifact and coprolite assemblage from the same levels, it is more likely that humans transported the seeds into what was then a dark cave.

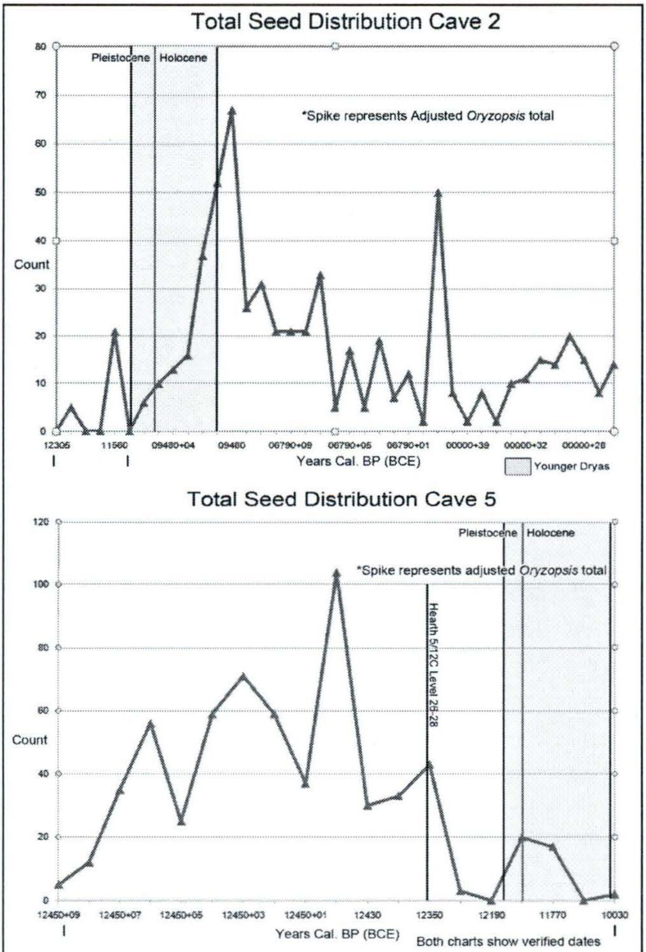

Table 1: Absolute count seed frequencies for all seeds identified

In Cave 5, by contrast, *Ceanothus* is highly represented for an extended period at a far earlier time. Whether the Cave 5 sample is due to human transport is debatable but still likely because of its association with other archaeological materials from the same level. It is unclear at this time

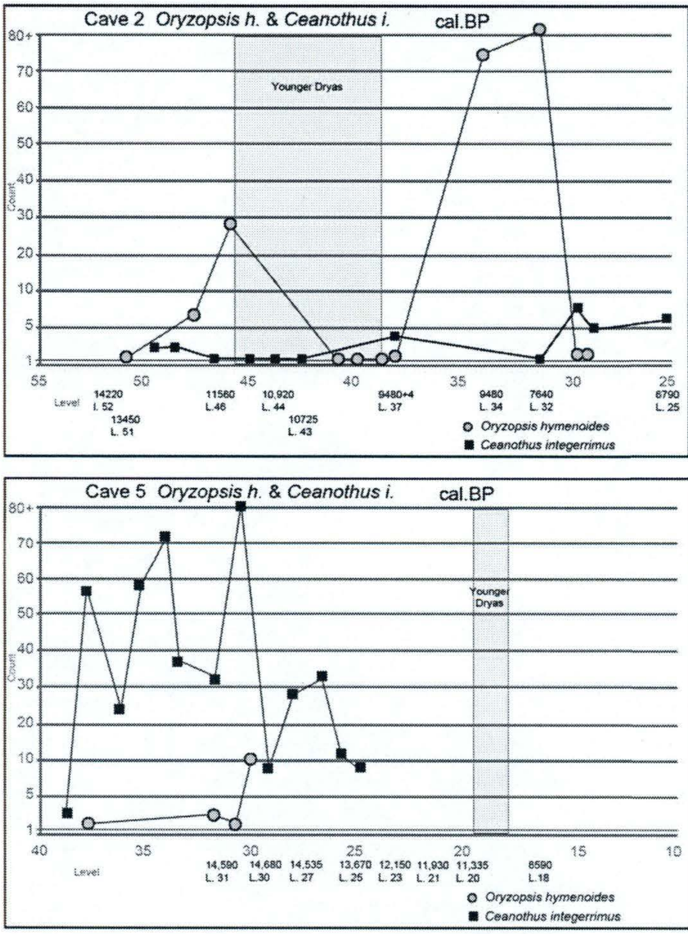

Table *2 Ceanothus* and *Oryzopsis* frequency variations by cave

whether *Ceanothus* grew on or near Five-Mile Butte before the end of the Pleistocene, although it is possible, as *Ceanothus* is drought tolerant and found in elevations up to 7,000 feet.

Oryzopsis is slightly better adapted to a warm, arid climate than *Ceanothus*. The high frequency of *Ceanothus* in Cave 5 may reflect the cooler, slightly wetter period in the Summer Lake Basin before the Younger Dryas. The high frequency of *Oryzopsis* in Cave 2 after the Younger Dryas may reflect the effects of significant warming during the Early Holocene.

Table 3 Botanical families and frequency percentages within total assemblage

Family	Genus/Species	Total	%
Asteraceae	*Artemisia tridentata*	1	0.06%
	Balsamorhiza hookerii	5	0.30%
Brassicaceae	*Arabis spp.*	6	0.06%
Cactaceae	*Opuntia fragilis*	3	0.18%
Chenopodiaceae	*Atriplex confertifolia*	35	2.10%
	Atriplex spp.	13	0.77%
Cupressaceae	*Juniperus spp.*	62	3.70%
Cyperaceae	*Carex spp.*	31	1.85%
	Scirpus spp.	2	0.12%
Fabaceae	*Astragalus speirocarpus*	4	0.24%
	Hedysarum spp.	1	0.06%
	Lupinus argentum	3	0.18%
Fagaceae	*Quercus spp.*	2	0.12%
Loasaceae	*Mentzalia laevicaulis*	67	3.99%
Pinaceae	*Pinus monophylla*	7	0.42%
Poaceae	*Oryzopsis hymenoides*	328	19.75%
	Festuca ovina	35	2.09%
Rhamnaceae	*Ceanothus spp.*	300	17.95%
	Ceanothus spp. (sepals)	286	17.04%
Rosaceae	*Prunus virginiana*	107	6.38%
	Salix spp.	32	1.90%
Other	*Other*	348	20.74%
	TOTAL:	**1678**	100.00%

The largest group of seeds identified were labeled "Other" includes a combination of unidentified twigs and many varieties of Poaceae (grasses). A future microbotanical study of "Other," which will likely show primarily Poaceae, may also indicate that little of the botanicals from Paisley Caves were for possible human consumption, and as a result may actually highlight the significance of the food seeds. At this stage of the research, however, it is enough simply to show their presence.

Accurately interpreted, the presence of food seeds can be as diagnostically valuable in the interpretation of a site as any other type of artifact. The frequency of food seeds present in the caves offer clues allowing us to estimate number of people, material preferences, frequency of visits to site, and so forth. In a similar manner, bone scatters may be associated with human behavior (Bahn and Renfrew, 2008, pp 190-192), and processing data from those scatters may contribute information ranging from diet, technology and population size approximations. However, without a permanent settlement, and as wild botanicals are naturally occurring and can be distributed in many different ways, we typically cannot assume that humans had anything to do with their presence within cave sites (Hastorf and Popper, 1989, pp 54,60,69). That uncertainty changes dramatically in areas of the world with known domesticates present in the house and storage floors (Lee and Bestel, 2007, pp 55-58). In those cases comparisons between weedy and domesticated seeds as well as between domesticate and domesticate can be used to obtain more reliable frequency patterns. Analysis of charred plant remains around identified hearth features could be subject to the same frequency pattern analysis that can be applied to lithics and other cultural remains.

Limitations of Study

Limitations to this study include sample sizes that are too small. Also, possible biases exist in selection. A further limitation is that the study focused only on macrobotanical remains. Microbotanical remains will be the next stage of this study and may contribute better frequency numbers for both early human presence and sensitive shifts in climate.

Bias may be further evident from initial lack of seed familiarity at the onset of this project so that it was sometimes a challenge to differentiate which materials were seeds and which were not. For instance, three scorpion stingers were selected for the study from the botanical bags. I selected these specimens for seed in the lab and then finally identified them only after identification of family and species had begun.

While unfamiliarity with seeds at the onset meant the possible selection of non seeds for study, this factor also complicated attempts to focus only on potential food-source seeds. At the time of sample selection, the intent was to remove as many seeds as possible without regard to potential food sources. Interestingly, during identification it became clear that most of the seeds identified were all possible human food sources. Some were definite, such as the enormous cache of *Oryzopsis hymenoides (Fig. 5)* and *Ceanothus integerrimus,* which were found in association with a confirmed hearth in Cave 5.

Conclusions

Major climate induced environmental changes at the end of the Pleistocene have been intensively studied in the Colombia River Plateau area (Fulton et al., 1989), but little has been written on paleoclimate in the Northern Great Basin region. The sudden transformative nature of the Missoula Floods notwithstanding, Fulton and other researchers have shown that the impacts of climate change at the end of the Pleistocene had a dramatic effect on the Colombia River Plateau region. From that fact we can infer that changes may have been just as dramatic farther south in the Northern Great Basin region.

Macrobotanical totals from Caves 2 and 5 are potentially culturally significant but only through comparison with archaeoethnobotanical information that strengthens the meaning of the numbers. For instance, it is more significant to find one *Pinus monophylla* (piñon) nut, which comes from central Nevada and likely transported by humans, than to find 100 *Oryzopsis hymenoides,* which produce seeds on many-headed clusters and are common in the Northern Great Basin.

The significance of the potential food seeds from Paisley is primarily due to their consumption by native people who inhabit the Great Basin and nearby areas and who have harvested the seeds for thousands of years. Klamath and Paiute ethnohistorical accounts provide a clear picture of traditional seed use and collection that has increased the potential significance of the Paisley seeds. This study would benefit from further efforts to go beyond simple species recognition and to correlate the seeds found at Paisley to ancient lore. Only then might the dynamic movements of the Northern Great Basin's people be better understood.

A targeted identification and microbotanical study of Poaceae and other small seeds through flotation sampling would add significant strength to the initial numbers shown in the tables here. Poaceae frequency would highlight high and low grass amounts and give a clearer picture of the environmental changes at the end of the Pleistocene.

Summary

The frequencies seen through absolute counts of macrobotanical assemblages excavated from Paisley Caves shows promising but inconclusive evidence of climatic and environmental change in the Summer Lake Basin at the end of the Pleistocene and the beginning of the Early Holocene (15,000-7,600 cal.BP). Clear evidence of a change in the macrobotanical assemblage marking the intense cold, dry period of the

Younger Dryas is also absent at this time, although again, some numbers are promising.

The size and distribution of the seed plants in the area of Five-Mile Point Butte and the apparent correlation of increased seed frequencies with cultural debris suggest that the probability of human macrobotanical transport is very high, and, in some cases, an almost absolute certainty. Such is the case of the *Pinus monophylla* (piñon) nut, which comes only from Nevada, and *Ceanothus integerrimus*, which is found in direct association with an apparent hearth in Cave 5 Unit 12C and dated to about 11,540 cal.BP. The distance and height of the caves from water sources are also strong indicators of the probability of human transport. Ultimately, although environmental change may be present but weakly supported, the macrobotanical materials appear to support evidence of early human sporadic occupations of the caves as early as 14,300 years ago, if not earlier.

Notes

[1] USDA Agricultural Research Pages: http://www.ars-grin.gov/npgs/images/sbml/

[2] Bend Seed Extractory: http://www.nps.gov/plants/sos/bendcollections/index.htm

Definitions

Archaeobotany: The study of past cultures through botanical remains recovered from archaeological context. It differs slightly from paleoethnobotany which looks at archaeobotanical remains from an ethnographic perspective. The terms are sometimes used interchangeably.

Pluvial Lake: A lake that experiences an increase in depth as a result of reduced evaporation due to low temperatures and/or an increase in precipitation or glacial runoff.

Macrobotanical: Any botanical remains in an archaeological context that can be observed with the unaided eye. Compared to *microbotanical* which requires the aid of magnification.

Metate: Flat grinding stone.

Riparian: The interface between land and a river or stream, or a river side ecological zone.

Coprolite: Desiccated or fossilized feces.

Lithic: Of stone, or artifact made of stone. Example: an arrowhead is a lithic point.

Lithosol: Stony or rocky ground.

Scoria: Macrovasicular volcanic rock.

Breccia: Loosely conglomerated, or weakly cemented pieces of volcanic rock.

Rainshadow: The blocking off of precipitation to a region by mountains.

Appendix

Table 4 Macrobotanicals identified at Paisley Caves 2 & 5

Family	Genus/Species	Common Name
Asteraceae	*Artemisia tridentate*	Sagebrush
Asteraceae	*Balsamorhiza hookerii*	Balsam Root
Brassicaceae	*Arabis spp. (drummondii or dispersa)*	Rockcress
Cactaceae	*Opuntia fragilis*	Prickly Pear Cactus
Chenopodiaceae	*Atriplex confertifolia*	Saltbush or Shadscale
Chenopodiaceae	*Atriplex spp.*	Unidentified species
Cupressaceae	*Juniperus spp. (monosperma)*	Juniper
Cyperaceae	*Carex spp.*	Sedge
Cyperaceae	*Scirpus spp.*	Rush
Fabaceae	*Astrogalus speirocarpus*	Milkvetch
Fabaceae	*Hedysarum spp.*	Sweetvetch
Fabaceae	*Lupinus argenteus*	Silvery Lupine
Fagaceae	*Quercus spp. (nigra)*	Oak
Loasaceae	*Mentzelia laevivaulis*	Blazing Star
Pinaceae	*Pinus monophylla*	Piñon Nut
Poaceae	*Oryzopsis Hymenoides*	Indian Ricegrass
Poaceae	*Festuca ovina*	Sheepgrass
Poaceae	*	Unidentified grass seeds
Rhamnaceae	*Ceanothus integerrimus*	Deer Brush
Rosaceae	*Prunus virginiana*	Chokecherry
Salicaceae	*Salix spp.*	Willow
Other		

Table 5 Total macrobotanicals from Paisley Caves 2 & 5

Caves/Units	Levels	Total Botanicals
2/4A	27-43	62
2/4B	31-43	46
2/4C	30-52	204
2/4D	30-40	119
	Total:	**431**
2/6A	26-47	241
2/6B	26-46	42
2/6C	28-47	72
2/6D	32-46	88
	Total:	**443**
5/11A	25-37	9
5/11B	30-37	20
	Total:	**29**
5/12A	25-36	310
5/12C	25-39	337
	Total:	**647**
5/13A	25-40	128
	Total:	**128**
	Total Botanicals:	**1678**

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