



# Paleoethnobotany at the LSP-1 rockshelter, south central Oregon: Assessing the nutritional diversity of plant foods in Holocene diet



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## ABSTRACT

This paper presents results of a paleoethnobotanical study using a nutritional ecology approach to investigate the contribution of plant foods to the diets of the occupants of LSP-1 (35HA3735), a modest rockshelter in Oregon's Warner Valley. Nutritional archeology offers an alternative to models derived from HBE for researchers interested in reconstructing prehistoric diet and understanding hunter-gatherer decision-making. Analysis of 7000+ individual seeds from archeological site deposits in the early (~10,000–7600 BP), middle (~7600–4000 BP), and late (~4000-contact) Holocene reveal temporal variations in the quantity of plant taxa targeted for consumption by visitors to LSP-1. Notably, the taxonomic and nutritional diversity of plant types present in the archeological deposits is elevated during late Holocene occupations of the rockshelter. Our results suggest that increases in dietary diversity correlate with periods of demographic expansion in Warner Valley and the northern Great Basin as a whole. These data contribute to a growing body of research proposing that the foraging pursuits of people participating in subsistence economies are not driven solely by caloric return rates.

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## 1. Introduction

Human behavioral ecology (HBE) has proven useful for studying hunter-gatherer populations (Bettinger 1991, 2009; Kelly, 2013; Winterhalder and Smith, 2000). HBE models provide robust and elegant frameworks for understanding prehistoric decision-making and how those decisions affected the distribution of archeological residues on the landscape. HBE has aided in understanding broad patterns of human behavior associated with subsistence, technology, land-use, and mobility (e.g., Byers and Broughton, 2004; Goodale and Andrefsky, 2015; Kelly, 2001; Morgan, 2012).

While capable of producing models that may be tested with empirical data, some HBE approaches may overemphasize the importance of net caloric gains as the primary motivator for choosing which foods to consume. For example, in traditional optimal foraging theory scenarios, mobile hunter-gatherers can access greater beneficial returns by focusing foraging activities on large-bodied animal resources (Kelly, 2013). Consequently, under these parameters plant foods, even starchy ones rich in carbohydrates, are often considered low-ranked resources due to prolonged search and processing times (Simms, 1987). The caloric and time expenditures necessary to acquire many plant resources can result in a sub-optimal net-energy gain relative to many animal

resources. Although plant foods are usually considered low-ranked resources, ethnographic data indicate that Great Basin foragers consumed taxa from over 50 families of plants (Fowler, 1986). As such, when the contribution of plant resources to prehistoric diets is overlooked in archeological analyses, it leaves a gap in our understanding of population-level health and demography.

Growing evidence suggests that some animals, including humans, regulate intake of multiple nutrients independently and, instead of maximizing caloric consumption, avoid ingesting surpluses and deficits relative to regulated nutrient intake (Simpson et al., 2004). As such, HBE models focusing on net energy gain alone may be insufficient to explain dietary choices. Because plant foods provide micro- and macronutrients that are essential to organ and tissue function, subsistence studies incorporating elements of nutritional ecology are better suited to address questions concerned with the effects of dietary choice because they also consider health consequences (Hockett, 2007; Hockett and Haws, 2003, 2005). Hockett and Haws (2003: 211) define nutritional ecology as “the study of the relationship between essential nutrient intake and its effects on overall human health, including growth and maintenance in individuals and general demographic trends in populations”. Simply put, nutritional ecology assumes that diverse diets that optimize micro- and macro-nutrient consumption decrease maternal and fetus-to-infant mortality rates, increase life expectancy, and in turn, contribute to population growth (Hockett and Haws, 2005). Hockett (2007) outlines that a primary prediction of nutritional archeology is that archeological assemblages containing diverse plant and animal

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resources should be correlated with periods of demographic expansion (i.e., population increase), which may be expressed as increases in radiocarbon dates, projectile points, or archeological sites.

In this paper, we use a nutritional archeology approach to investigate the contribution of plant foods to the diets of the occupants of LSP-1 (35HA3735), a modest rockshelter in Oregon's Warner Valley that was occupied episodically throughout much of the Holocene (Pellegrini, 2014; Smith et al., 2012, 2014). We describe the analysis of macrobotanical remains recovered from a stratigraphic column and cultural features at LSP-1 to address two research questions: (1) which plant resources were consumed by the occupants of the site?; and (2) are there correlations between dietary diversity, the nutritional contributions provided by wild plant consumption, and larger demographic patterns in Warner Valley during the Holocene?

## 2. Background: the LSP-1 rockshelter

### 2.1. Ecological and physical setting

LSP-1 is located in northern Warner Valley in the High Desert Ecological Province of southcentral Oregon (Anderson et al., 1998). The area is distinguished by basin-and-range topography and pluvial basins that intermittently hold water. The region receives relatively little rainfall (~25 cm annually) and most precipitation falls as snow in the winter months (Oregon Climate Service, 2015). Vegetation is characterized by

a sagebrush and perennial grass-dominated shrub-steppe environment. Drought-tolerant plants such as big sagebrush (*Artemisia tridentata*), rabbitbrush (*Ericameria* sp.), needlegrass (*Nasella* sp.), Indian ricegrass (*Oryzopsis hymenoides*), and squirreltail (*Elymus elymoides*) are common on upland slopes (Franklin and Dyness, 1988). In wetter years, the lowlands collect more water and as recently as the 1860s, parts of northern Warner Valley were overgrown by freshwater marsh plants such as tule (*Schoenoplectus acutus*) and cattail (*Typha latifolia*) (Whistler and Lewis, 1916). Currently, the nearest basin that periodically supports a wetland is Bluejoint Lake, located ~10 km southeast of LSP-1.

LSP-1 is the largest in a series of wave-cut rockshelters situated at the base of a welded tuff formation recorded as a single site, 35HA3735. It contains ~50 m<sup>2</sup> of habitable area within the dripline (Fig. 1). It formed when Pleistocene Lake Warner was at or near its highstand and subsequently infilled with alluvial and aeolian sediment intermixed with roof fall (Smith et al., 2014). From 2010 to 2015, crews from the University of Nevada, Reno's Great Basin Paleohuman Research Unit (GBPRU) excavated ~25 m<sup>2</sup> of deposits from units that reached ~1.5–2 m below surface. Ten distinct strata were encountered (Fig. 2), which are described elsewhere in detail by Smith et al. (2014). These were lumped into three major sediment packages, which reflect different time periods and depositional regimes. The upper package consists of historic cattle manure (Stratum I) overlying inter-fingering fine- and coarse-grained facies (strata II and IV) of an alluvial fan located



Fig. 1. Planview of the LSP-1 rockshelter showing excavation grid and the locations of the features and column sample discussed in the text.

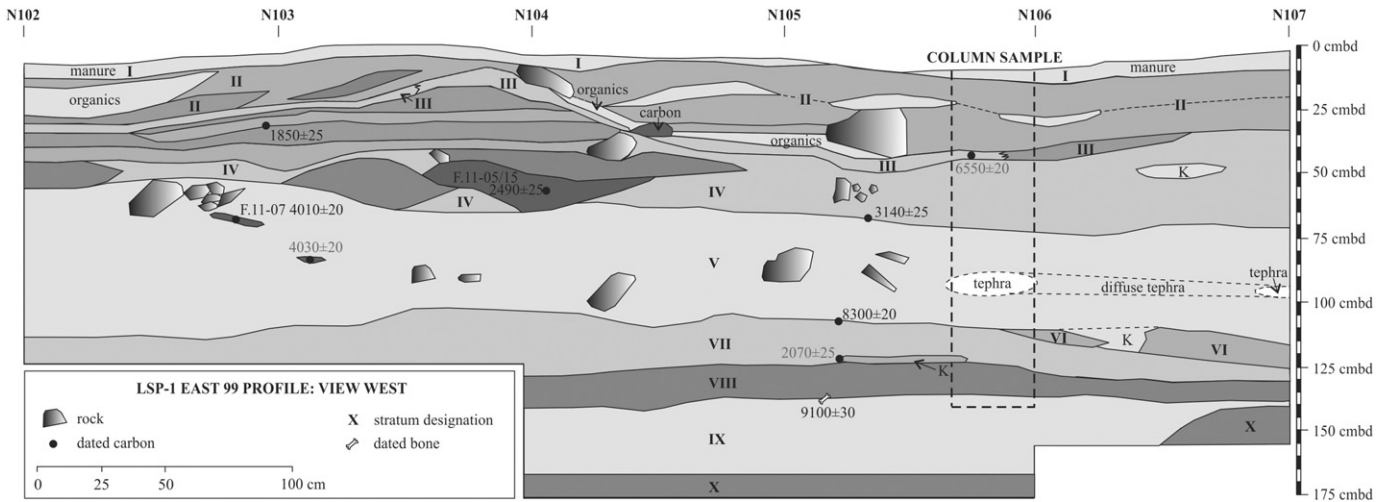


Fig. 2. West profile of the E99 trench showing the various strata, locations of radiocarbon-dated samples collected from the profile (suspect dates shown in gray), and stratigraphic column sample.

**Table 1**  
Radiocarbon dates from LSP-1 arranged from youngest to oldest. Bolded dates are the focus of this paper.

Sample ID	FS number	Excavation unit	cmbd	Stratum	Dated material	<sup>14</sup> C age	2σ cal BP range	Comments	Reference(s)
Beta-283901	45	N105E99	62	IV	Unidentified charcoal	880 ± 40	915–706		Smith et al. (2014)
<b>D-AMS 0010587</b>	<b>n/a</b>	<b>N104E99/100</b>	<b>50</b>	<b>II/III</b>	<b>Juniperus seeds</b>	<b>1013 ± 29</b>	<b>976–803</b>	<b>Feature 11-14 (hearth)</b>	<b>Current study</b>
UGA-16860	427	N103E102	82	V	Catlow Twine textile	1160 ± 20	1175–989	Woodrat nest	Smith et al. (2016)
<b>D-AMS 0010596</b>	<b>CS25B</b>	<b>N104E99</b>	<b>128–131</b>	<b>VIII</b>	<b>Artemisia charcoal</b>	<b>1173 ± 25</b>	<b>1179–1000</b>	<b>Column sample</b>	<b>Current study</b>
UGA-16859	426	N103E101	81	V	Catlow Twine textile	1200 ± 20	1180–1063	Woodrat nest	Smith et al. (2016)
AA-103861	n/a	n/a	n/a	n/a	Textile fragment	1230 ± 36	1264–1065	Woodrat nest	Previously unreported
<b>D-AMS 0010590</b>	<b>CS8A</b>	<b>N104E99</b>	<b>41–44</b>	<b>III</b>	<b>Artemisia charcoal</b>	<b>1255 ± 24</b>	<b>1277–1088</b>	<b>Column sample</b>	<b>Current study</b>
UGA-18238	1302	N102E103	66	n/a	sagebrush sandal	1300 ± 20	1287–1183	Feature 14-10 (storage pit)	Smith et al. (2016)
UGA-18237	1298	N102E103	59	n/a	sagebrush bark bundle	1340 ± 20	1302–1190	Feature 14-10 (storage pit)	Smith et al. (2016)
UGA-18239	1309	N102E103	62	n/a	sagebrush sandal	1760 ± 20	1721–1610	Feature 14-10 (storage pit)	Smith et al. (2016)
UGA-18235	1293	N101E103	52	n/a	Catlow Twine textile	1790 ± 20	1813–1625	Feature 14-10 (storage pit)	Smith et al. (2016)
UGA-16803	712	N102E99	33	IV	Unidentified charcoal	1850 ± 25	1865–1716		Previously unreported
UGA-18236	1297	N102E103	62	n/a	sagebrush sandal	1860 ± 20	1865–1729	Feature 14-10 (storage pit)	Smith et al. (2016)
UGA-18240	1311	N102E103	76	n/a	sagebrush sandal	1880 ± 20	1879–1737	Feature 14-10 (storage pit)	Smith et al. (2016)
UGA-15596	715	N105E99	123	VII	<i>Artemisia</i> charcoal	2070 ± 25	2122–1951		Previously unreported
UGA-16800	<b>709</b>	<b>N104E99</b>	<b>57</b>	<b>IV</b>	<b>Unidentified charcoal</b>	<b>2490 ± 25</b>	<b>2723–2473</b>	<b>Feature 11-05/15 (hearth)</b>	<b>This study</b>
<b>Beta-317155</b>	<b>n/a</b>	<b>N104E99</b>	<b>72</b>	<b>IV</b>	<b>Unidentified charcoal</b>	<b>2910 ± 30</b>	<b>3158–2960</b>	<b>Feature 11-19 (hearth)</b>	<b>Smith et al. (2012)</b>
<b>D-AMS 0010591</b>	<b>CS12</b>	<b>N104E99</b>	<b>61–66</b>	<b>IV</b>	<b>Artemisia charcoal</b>	<b>3038 ± 26</b>	<b>3343–3166</b>	<b>Column sample</b>	<b>Current study</b>
<b>D-AMS 0010593</b>	<b>CS16</b>	<b>N104E99</b>	<b>81–86</b>	<b>V</b>	<b>Artemisia charcoal</b>	<b>3046 ± 31</b>	<b>3350–3170</b>	<b>Column sample</b>	<b>Current study</b>
<b>D-AMS 0010592</b>	<b>CS13</b>	<b>N104E99</b>	<b>66–71</b>	<b>IV</b>	<b>Artemisia charcoal</b>	<b>3090 ± 26</b>	<b>3371–3231</b>	<b>Column sample</b>	<b>Current study</b>
UGA-15593	706	N105E99	67	IV/V	cf. <i>Rhus</i> charcoal	3140 ± 25	3444–3257		Previously unreported
Beta-406150	1251	N102E102	72	IV	<i>Salix</i> charcoal	3160 ± 30	3450–3272	Feature 14-06 (hearth)	Smith et al. (2016)
<b>D-AMS 0010588</b>	<b>n/a</b>	<b>N102E100/101</b>	<b>66</b>	<b>IV</b>	<b>Cordage</b>	<b>3987 ± 26</b>	<b>4522–4415</b>	<b>Feature 14-02 (hearth)</b>	<b>Current study</b>
<b>D-AMS 0010589</b>	<b>982</b>	<b>N102E99/100</b>	<b>74–75</b>	<b>IV</b>	<b>Artemisia charcoal</b>	<b>3990 ± 26</b>	<b>4522–4416</b>	<b>Feature 14-04 (hearth)</b>	<b>Current study</b>
UGA-14917	476	N103E101	96	V	<i>Artemisia</i> charcoal	4000 ± 25	4522–4420		Smith et al. (2014)
<b>UGA-16801</b>	<b>710</b>	<b>N102E99</b>	<b>68</b>	<b>V</b>	<b>Unidentified charcoal</b>	<b>4010 ± 20</b>	<b>4522–4425</b>	<b>Feature 11-07 (hearth)</b>	<b>Previously unreported</b>
UGA-15260	409	N104E101	82	V	<i>Bison</i> femur	4010 ± 25	4525–4422		Smith et al. (2014)
<b>D-AMS 0010595</b>	<b>CS22</b>	<b>N104E99</b>	<b>111–116</b>	<b>VII</b>	<b>Artemisia charcoal</b>	<b>5238 ± 26</b>	<b>6174–5921</b>	<b>Column sample</b>	<b>Current study</b>
UGA-15595	714	N105E99	45	III/IV	Unidentified charcoal	6550 ± 20	7490–7425		Previously unreported
Beta-306418	38	N105E99	142	VII	Unidentified charcoal	7310 ± 40	8186–8021		Smith et al. (2012)
<b>D-AMS 0010597</b>	<b>CS26</b>	<b>N104E99</b>	<b>131–136</b>	<b>VIII</b>	<b>Artemisia charcoal</b>	<b>7944 ± 35</b>	<b>8980–8644</b>	<b>Column sample</b>	<b>Current study</b>
<b>D-AMS 0010594</b>	<b>CS20</b>	<b>N104E99</b>	<b>101–106</b>	<b>V</b>	<b>Artemisia charcoal</b>	<b>8263 ± 38</b>	<b>9408–9124</b>	<b>Column sample</b>	<b>Current study</b>
Beta-282809	46	N105E99	120	VI	Unidentified charcoal	8290 ± 40	9427–9137		Smith et al. (2012)
UGA-18011	1129	N107E99	131	VIII	<i>Lepus</i> ulna	8290 ± 25	9420–9143	Presumably non-cultural	Previously unreported
UGA-15594	707	N105E99	106	V/VII	cf. <i>Rhus</i> charcoal	8300 ± 20	9422–9252		Previously unreported
Beta-287251	48	N105E99	103	V	Unidentified charcoal	8340 ± 40	9470–9261		Smith et al. (2012)
PRI-14-069	1130	N107E99	124	VI/VII	<i>Artemisia</i> charcoal	8341 ± 27	9449–9289		Previously unreported
UGA-14916	431	N103E101	86	V	<i>Artemisia</i> charcoal	8350 ± 30	9462–9296		Smith et al. (2014)
Beta-297186	47	N105E99	131	VI/VII	Unidentified charcoal	8400 ± 50	9520–9301		Smith et al. (2012)
Beta-306419	158	N102E99	97	V	Unidentified charcoal	8670 ± 40	9731–9540		Smith et al. (2012)
<b>UGA-15142</b>	<b>n/a</b>	<b>N103E100</b>	<b>125</b>	<b>V</b>	<b>Artemisia charcoal</b>	<b>8700 ± 30</b>	<b>9735–9550</b>	<b>Feature 13-01 (hearth)</b>	<b>Smith et al. (2014)</b>
UGA-15259	716	N105E99	141	VIII/IX	<i>Sylvilagus humerus</i>	9100 ± 30	10,293–10,200	Presumably non-cultural	Smith et al. (2014)

Note. All dates were calibrated using OxCal 4.2 (Ramsey, 2009) and the IntCal 13 Curve (Reimer et al., 2013).

immediately adjacent to LSP-1. These facies are separated by a thin layer of aeolian sand (Stratum III). Radiocarbon dates on hearth features, organic artifacts, and isolated charcoal fragments from across the site indicate that the upper package began accumulating after ~3000 cal BP (Table 1).

The middle package consists of a massive unit of poorly-sorted fan gravel intermixed with fine to very fine sand (Stratum V) and a unit of massive, silty, very fine aeolian sand (Stratum VI). Small pockets of Mazama tephra are found midway through Stratum V in the western portion of the site. Although a few out-of-sequence radiocarbon dates suggest that the deposits are mixed in some places, the majority indicate that the middle sediment package spans the period from ~3000 to ~9650 cal BP (see Table 1). The middle sediment package – in particular, Stratum V – is the primary artifact bearing unit at LSP-1. It produced abundant flaked and ground stone artifacts and a rich and well-preserved faunal assemblage. Analysis of these artifacts is ongoing but preliminary results suggest that visitors to the site were far-ranging and had access to numerous obsidian sources throughout the northern Great Basin (Smith et al., 2012). Based on his analysis of a sample of fauna from the site, Pellegrini (2014) concluded that LSP-1 was primarily occupied during the fall or winter months, during which time groups field-processed large numbers of leporids. He suggests that the animals were mass harvested to provide both food and fur for robe or blanket manufacture. The presence of over 200 ground stone artifacts recovered throughout the cultural deposits suggests that plant processing was also an important activity at LSP-1. Gaps in the projectile point sequence and radiocarbon dates from the site strongly suggest that following its initial occupation ~9650 cal BP, LSP-1 was abandoned between ~9300 and ~4500 cal BP – a period that encompasses the middle Holocene (Pattee, 2014).

The lower sediment package consists of alternating bands of coarse gravel (strata VII and IX) and black sand (strata VIII and X). The coarse gravel was likely deposited as sediment stored against the welded tuff formation initially unloaded into the shelter while the black sand represents autogenic sediment weathered from the shelter's walls. No Pleistocene-age radiocarbon dates have been obtained on the lower package deposits due to a paucity of preserved organics, but radiocarbon dates on presumably non-cultural leporid bones indicate that it continued to accumulate into the early Holocene (see Table 1).

### 3. Materials and methods

Materials analyzed for this study were recovered as bulk sediment samples from LSP-1 deposits following standard extraction techniques (Pearsall, 2000). Basic procedures for macrobotanical analysis were adopted from Cummings (1989) and represent a modification of procedures outlined by Matthews (1979). Fragmented and deteriorated seeds were excluded from the analysis. Although charred starchy and fruity tissues probably represent plant food debris, they have not yet been analyzed to ascertain taxonomic identification and as a result have also been omitted for this study. All statistical calculations were made using JMP 10 software.

Stratigraphic grab samples were collected from a column in the west profile of excavation unit N105E99 following a 5-cm vertical sampling technique (Fig. 3). When stratigraphic changes were visible, samples were collected separately within each 5-cm level. In total, 25 samples ranging in depth from 28 to 141 cm below datum (cmbd) were recovered from strata II–IX for macrobotanical analysis; these were collected over 113 contiguous vertical centimeters. Ten samples were collected from the upper sediment package (strata II–IV), nine samples were collected from the artifact-rich middle sediment package (strata V–VII), and six samples were collected from the lower sediment package (strata VIII–IX). Chronological control was established over the samples using previously reported radiocarbon dates and age estimations for the

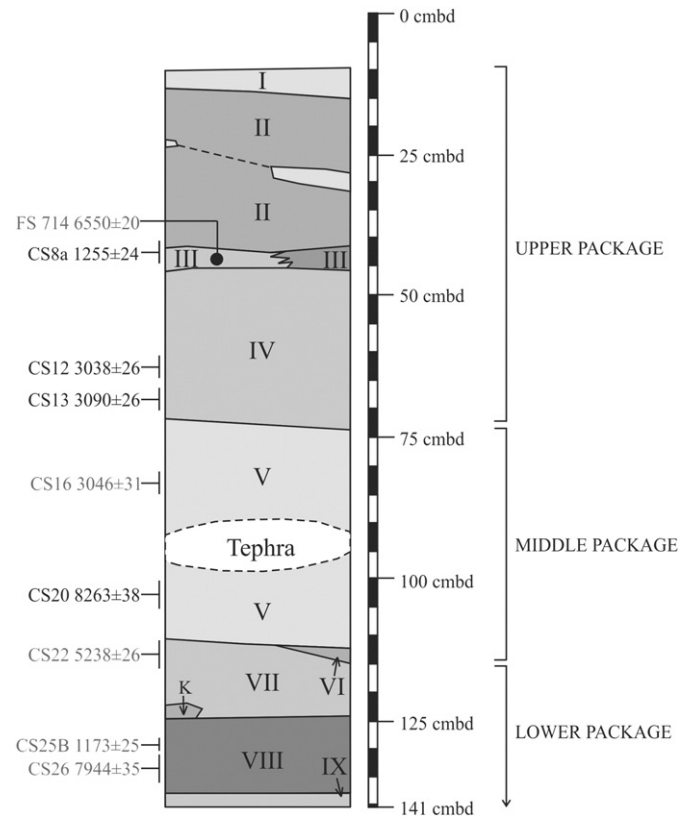


Fig. 3. Close-up of stratigraphic column sample with depths of radiocarbon dated samples (suspect dates shown in gray).

various strata as well as eight new AMS dates obtained on material collected from the column itself (see Fig. 3). While there is general agreement between previous age estimates and the new AMS dates, several column sample dates appear out of the correct vertical sequence, suggesting that some degree of vertical mixing has occurred in that part of the LSP-1 deposits. Most notably, an isolated fragment of sagebrush charcoal (CS25B) collected from 128–131 cmbd in the column, 30+ cm below Mazama tephra deposited ~7700 cal BP (Bacon, 1983), produced a date of  $1173 \pm 25$   $^{14}\text{C}$  BP (~1100 cal BP). The charcoal was recovered next to a clearly defined infilled rodent burrow that also produced an aberrant date of  $2070 \pm 25$   $^{14}\text{C}$  BP (~2050 cal BP). A few exceptions aside, dated samples from within the stratigraphic column fall within our age estimations for the upper, middle, and lower sediment packages.

In addition to samples collected from the stratigraphic column by one of the authors (Kennedy), bulk feature samples were also collected in situ by GBPRU crewmembers as hearths were encountered during excavations. Samples from nine such features, seven of which have been AMS dated and range in age from ~925 cal BP to ~9650 cal BP, were included in our study (see Fig. 1 and Table 1). Macrobotanical remains from those features provide data regarding the plants collected by the site occupants for food or to a lesser extent, fuel, while the macrobotanical remains contained in the stratigraphic samples allow us to understand the local vegetation regime and paleoenvironmental conditions that existed in northern Warner Valley throughout the Holocene. Together, these two datasets provide the best possible understanding of dietary choices made by the groups that occupied LSP-1.

Samples used in this analysis varied in volume but 1 L was processed when adequate amounts of sediment matrix were available. The decision to analyze non-standardized sample volumes was made to ensure that the natural strata were processed independently. To overcome any discrepancies stemming from the comparison of constituents recovered



**Table 2**  
Identified plant taxa recovered from the stratigraphic column sample grouped by sediment package and normalized to account for volumetric differences. Numbers in parentheses represent percent of seeds within each column.

Taxa	Sediment package						Total
	Upper		Middle		Lower		
	Uncharred	Charred	Uncharred	Charred	Uncharred	Charred	
<i>Borage family</i>	1 (0.0%)	2 (0.4%)	1 (0.8%)	–	–	–	4
Fiddleneck	39 (1.5%)	–	92 (76.0%)	–	65 (32.0%)	–	196
<i>Cheno-am</i>	849 (32.0%)	23 (4.6%)	2 (1.7%)	–	128 (63.0%)	14 (18.4%)	1016
Saltbush	1429 (53.8%)	–	4 (3.3%)	1 (2.3%)	–	1 (1.3%)	1435
Chenopod	317 (11.9%)	339 (67.5%)	15 (12.4%)	26 (59.1%)	7 (3.5%)	25 (32.9%)	730
<i>Grass family</i>	–	1 (0.2%)	–	–	–	–	1
Bentgrass	–	44 (8.8%)	–	5 (11.3%)	–	8 (10.5%)	57
GB wildrye	–	–	–	–	–	3 (3.9%)	3
<i>Mustard family</i>	–	–	2 (1.7%)	–	–	–	2
Tansymustard	–	63 (12.5%)	–	8 (18.2%)	–	–	71
Blazing star	16 (0.6%)	2 (0.4%)	5 (4.1%)	–	3 (1.5%)	–	26
Cattail	–	–	–	–	–	1 (1.3%)	1
Stinging nettle	4 (0.2%)	–	–	–	–	–	4
Phacelia	–	1 (0.2%)	–	–	–	–	1
Unidentified	–	27 (5.4%)	–	4 (9.1%)	–	24 (31.7%)	55
Total	2655 (100.0%)	502 (100.0%)	121 (100.0%)	44 (100.0%)	203 (100.0%)	76 (100.0%)	3601

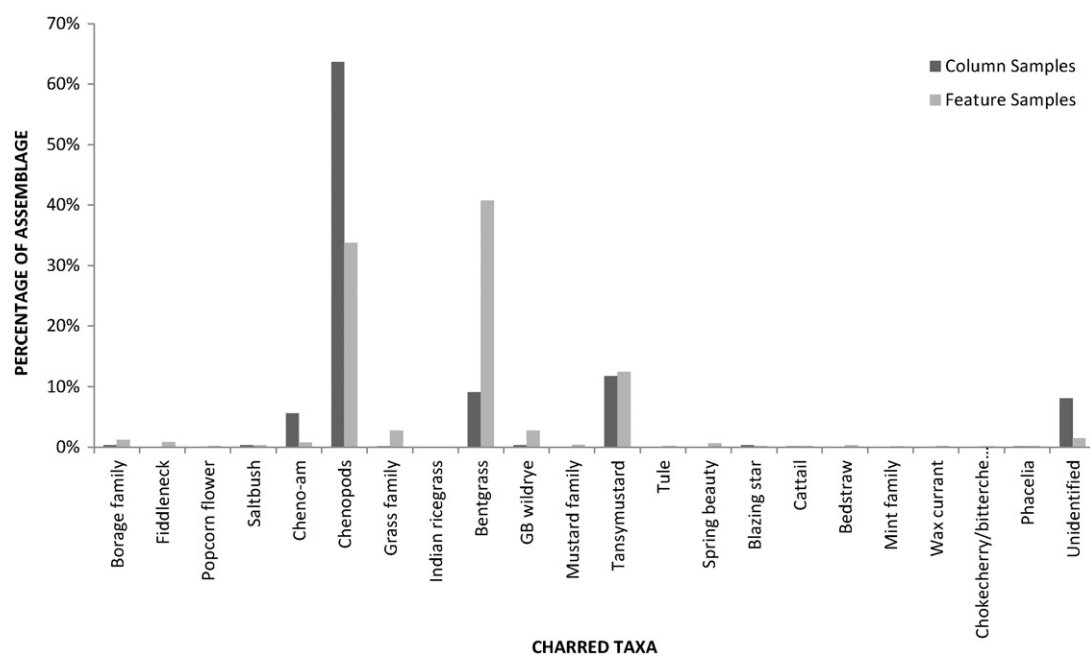
from samples of differing sizes, density calculations were made for each sample. The samples were floated and sieved through a set of nested screens to recover all botanical constituents greater than 250  $\mu\text{m}$ . Sieving the sediments through fine mesh screens allows the identification of very minute elements that are easily missed in situ or during on site screening of the excavated matrix. To aid in identification, all constituents were scanned under a Nikon binocular stereo zoom microscope. Plant remains were identified to the most specific taxonomic level possible and made with the assistance of a modern reference collection and seed identification keys (Cappers et al., 2009; Davis, 1993; Martin and Barkley, 1973). The reference specimens reflect field collection efforts in Lake, Harney, and Malheur counties as well as the sanctioned destructive sampling of herbarium specimens at Oregon State University and the Malheur National Wildlife Refuge. Nutritional data were provided by the USDA National Nutrient Database for Standard Reference, Release 27 (USDA, 2015). Ethnobotanical data for the Paiute, Klamath, and Modoc tribes that occupied the northern Great Basin during historic times (Coville, 1897; Fowler, 1990; Kelly, 1932; Mahar,

1953; Murphey, 1959; Park and Fowler, 1989; Ray, 1973) furnished interpretive contexts for recognizing traditional foods among the plant taxa identified in this analysis.

## 4. Results

### 4.1. Stratigraphic column samples

Macrobotanical remains recovered from the column samples include seeds, wood, charcoal, charred starchy and fruity tissues, herbaceous stems, and nutshell. A cursory examination of the wood and charcoal revealed that on average, sagebrush comprises more than 80% of the total woody material in the samples. Analysis of the 3538 seeds recovered from the column samples identified 10 taxa belonging to eight plant families; these include chenopods (*Chenopodium* sp.), saltbush (*Atriplex* sp.), grasses including Great Basin wildrye (*Leymus cinereus*) and bentgrass (*Agrostis* sp.), tansymustard (*Descurainia* sp.) and other unidentified mustards, fiddleneck (*Amsinckia* sp.) and other



**Fig. 4.** Comparison of identified charred macrobotanical remains from column samples and features.

**Table 3**  
Identified charred plant taxa recovered from LSP-1 features.

Feature ID	<sup>14</sup> C date	2σ cal BP range	Taxa													Total								
			Storage	Fiddleneck	Popcorn Flower	Cheno-ams	Saltbush	Chenopods	Grass Family	Bentgrass	Great Basin Wildrye	Mustard Family	Tansymustard	Tule	Spring Beauty		WS Blazing Star	Cattail	Bedstraw	Mint Family	Wax Currant	Chokecherry/ bittercherry	Phacelia	Unidentified
11-14	1013 ± 29	976–803	5	2	1	-	-	48	2	26	3	12	-	2	1	1	1	1	1	-	-	-	4	110
11-05/15	2490 ± 25	2723–2473	2	-	-	-	136	4	-	7	73	2	2	1	-	-	-	1	1	1	1	1	9	239
11-19	2910 ± 30	3158–2960	-	1	-	-	48	-	1	2	2	2	2	2	-	-	-	-	-	-	-	1	-	58
14-02	3987 ± 26	4522–4415	-	-	1	3	66	5	1	13	19	-	-	-	-	-	-	-	-	-	-	-	-	108
14-04	3990 ± 26	4522–4416	-	-	-	-	4	-	24	2	-	-	-	-	-	-	-	-	-	-	-	-	-	31
11-07	4010 ± 20	4522–4425	2	-	-	-	1	-	327	-	-	-	-	1	-	-	-	-	-	-	-	-	-	331
14-03	Undated <sup>a</sup>	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
13-01	8700 ± 30	9735–9550	2	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	6
13-02	Undated <sup>b</sup>	-	6	-	3	-	9	15	-	-	9	-	-	-	-	-	-	-	-	-	-	1	44	

<sup>a</sup> Feature 14-03 is currently undated but is likely late Holocene in age.  
<sup>b</sup> Feature 13-02 is currently undated but is likely early Holocene in age.

members of the borage family, phacelia (*Phacelia* sp.), white-stemmed blazing star (*Mentzelia albicaulis*), cattail, and stinging nettle (*Urtica dioica*) (Table 2). Roughly 17% of the seeds in the samples were carbonized. When the seed data are normalized to account for volumetric differences in sample size, 87.7% of the total seed assemblage was recovered from samples in the upper sediment package, which post-dates ~3000 cal BP. Samples from the artifact-rich middle sediment package, which dates to ~3000–9650 cal BP, produced only 4.6% of the total seed assemblage. Finally, samples from the lower sediment package, which predates ~9650 cal BP, produced 7.7% of all identified seeds. The primary taxa associated with the upper package samples are uncharred cheno-am and saltbush seeds. Uncharred fiddleneck seeds are the dominant taxon identified in the middle package samples. The lower package samples primarily contained uncharred cheno-ams and fiddleneck seeds. Although relatively less abundant in the column samples, charred seeds represented unique taxonomic types, including grasses and tansymustard.

4.2. Feature samples

Nine hearth features were sampled and analyzed for macrobotanical remains. Seeds/fruits, charcoal and wood, leaves, stems, and charred plant tissues were recovered from the feature samples (Supplemental Table 1). Analysis of 3439 seeds recovered from features identified 17 individual taxa representing 11 plant families. Identified taxa include chenopods and saltbush, Great Basin wildrye, bentgrass, Indian ricegrass and other grass genera, borages including fiddleneck and popcorn flower (*Plagiobothrys* sp.), tansymustard and other mustard family members, spring beauty (*Claytonia* sp.), bedstraw (*Galium* sp.), mint (Lamiaceae), phacelia, white-stemmed blazing star, cattail, wax currant (*Ribes sanguineum*), chokecherry or bittercherry (*Prunus* sp.), and coyote tobacco (*Nicotiana attenuata*). Unsurprisingly, charred seeds were more abundant in the feature samples than the column samples and comprised 27.2% of the overall seed assemblage. Although there is some overlap in the charred taxa identified in features and column samples, the botanical remains observed in the feature samples represented a broader range of plant types (Fig. 4).

The analysis of the features' contents indicates that the plant resources consumed by the site's occupants varied through time (Table 3). In the terminal early Holocene features (13-01 and 13-02) carbonized plant remains are limited to grasses, cheno-ams, and mustards. Conversely, in the late Holocene features (11-05/15, 11-07, 11-14, 11-19, 14-02, 14-03, and 14-04) the charred seeds represent a more diverse taxonomic array, including marsh plants. We discuss the implications of these differences below.

5. Discussion

Although some taxa (e.g., chenopods) are represented in the charred and uncharred assemblages from the column and feature samples, others including Indian ricegrass and saltbush occur only as uncharred specimens. As Rhode and Louderback (2007) note, myriad site formation and post-depositional taphonomic processes contribute to the accumulation of macrobotanical remains in rockshelters. While this is true to a certain extent for features as well, charred seeds – especially those found in hearths – are typically interpreted to represent food debris either intentionally or accidentally carbonized in cooking fires (Lepofsky et al., 2001; Miller, 1989). If uncharred taxa in the column samples primarily reflect human activity, then there should be no significant difference between charred and uncharred seeds. A chi-square test comparing the two samples indicates that this is not the case ( $\chi^2 = 2002.65$ ,  $df = 14$ ,  $p < 0.005$ ), suggesting that the uncharred remains – in particular, Indian ricegrass and saltbush – may not reflect human activity. The fact that these taxa are popular targets for rodent seed-caching (Longland and Ostojka, 2013) greatly reduces our confidence in associating uncharred taxa with human diet, especially since

concentrations of uncharred seeds were periodically encountered in krotovina during site excavations. Additionally, the plants represented by uncharred seeds bloom earlier on average (March through June) than those plants represented by charred seeds (June through October); the discrepancy in timing suggests that the uncharred seeds are unrelated to cultural activity (Calflora, 2015). While the uncharred seeds may not reveal much about human diet at LSP-1, they are nonetheless helpful for reconstructing the environment around the rockshelter at different points in time because the rodents that collect them forage relatively short distances from their nests.

### 5.1. Northern Warner Valley Holocene ecology

Both charred and uncharred seeds provide data about those plant resources available in the vicinity of LSP-1 at various times throughout the Holocene. Although analysis of uncharred seeds outside cultural features cannot confidently predict plant food types targeted by site occupants, they likely represent taxa growing near and around the site at the time of deposition. Based on the relatively higher contribution of grass seeds and virtual absence of saltbush seeds in the Lower Package deposits, the early Holocene at LSP-1 represented a period of increased moisture when compared to the middle and late Holocene. The spike in saltbush seeds in the late Holocene suggests that drier conditions in the immediate vicinity of the site were not established until after ~3000 cal BP when the upper package deposits began accumulating. When placed within the larger context of regional paleoclimate studies, these results demonstrate a record of fluctuations in local environmental conditions in northern Warner Valley during the Holocene. Both Wriston and Smith (2012) and Weide (1975) suggest that pluvial Lake Warner had retreated from the valley floor below LSP-1 by ~9650 cal BP, around the time the site was first occupied, but it is likely that the smaller lakes found in northern Warner Valley today (e.g., Bluejoint, Campbell) periodically rose and fell during the Holocene in a manner similar to that observed during historic times (Cannon et al., 1990). In southern Warner Valley, Hansen's (1947) analysis of pollen cores indicates that saltbush peaked during the middle Holocene, suggesting that conditions were warmer and drier at that time. Wigand and Rhode's (2002) analysis of pollen from Bicycle Pond, located 300+ m above the valley floor in southern Warner Valley, indicates that grasses were more common during the early Holocene while the middle Holocene was marked by a retreat of juniper woodland and expansion of sagebrush.

### 5.2. Prehistoric plant consumption at LSP-1

Focusing only on the charred plant remains from the features, which, again likely reflect food residues, permits further analysis of diet and nutrition. Ethnographic accounts indicate that many of the charred taxa present in the LSP-1 samples – chenopods, bentgrass, Great Basin wildrye, tansymustard, cattail, and possibly white-stemmed blazing star – figured prominently in the subsistence economies of northern Great Basin groups (Coville, 1897; Kelly, 1932; Mahar, 1953; Park and Fowler, 1989; Ray, 1973). The seeds of chenopods, tansymustard, various grasses, and white-stemmed blazing star were common foods of the Paiute and Klamath tribes (Coville, 1897:91, 95–96; Kelly, 1932:98; Murphey, 1959:27; Park and Fowler, 1989:47). Cattail was harvested for consumption of its seeds, pollen and rootstock (Coville, 1897:90; Park and Fowler, 1989:48–49, 1990:69). Park and Fowler (1989) note that the seeds of the plants listed above were frequently dried and stored for winter use. This observation supports the interpretation that LSP-1 was primarily occupied during the fall and winter months when leporids were processed here.

Features representing early Holocene cultural activity indicate a moderate reliance on local wild plant foods, including cheno-ams, small grass seeds, and tansymustard. Charred seeds of Great Basin wildrye were also present in the early Holocene deposits. All of these

plants would have been available during the late spring through early fall months. Based on the presence of charred cattail seeds in the lower package column samples, there is also limited evidence suggesting that people intermittently utilized marshland resources, which would have been available within 10 km of the site. The earliest inhabitants of LSP-1 apparently had a broad and diverse diet containing items procured from various resource zones. Evidence for a broad spectrum diet in the early Holocene has been documented elsewhere in the Great Basin at sites like the Paisley Five Mile Point Caves (Jenkins et al., 2013) and Bonneville Estates Rockshelter (Hockett, 2007).

The upper package hearth features contain hundreds of charred seeds indicating an elevated reliance on plant foods. These results also suggest that the contribution of plant foods to diet was increasingly diverse during the late Holocene. In addition to locally available grasses, cheno-ams, and mustards, tule and cattail reflect the exploitation of nearby wetland resources, and wax currant and chokecherry/bittercherry seed fragments suggest that groups foraged in upland contexts. A higher frequency of ground stone artifacts throughout the upper package deposits also signifies the increased importance of plant foods at this time.

The USDA national database provides nutrient composition data for some but not all of the wild plants documented at LSP-1; they show that chenopods, grasses, and cattail each contribute essential nutrients such as vitamins A, C and K, folate, calcium, phosphorus, and dietary fiber that could not be obtained from diets dependent on meat alone (USDA, 2015) (Table 4). Fruits of currants and chokecherries also provide higher levels of vitamin C, potassium, and trace minerals (USDA, 2015). Hockett (2007) has noted that if the assumptions of nutritional ecology are correct, then we should expect to see periods of greater nutritional diversity correlated with demographic expansion and/or improved health conditions while restricted nutritional diversity should be associated with demographic downturns.

Demographic expansions in the northern Great Basin are well documented during both the early and late Holocene (Aikens et al., 2011), including northern Warner Valley. Pattee's (2014) analysis of survey data from the valley immediately surrounding LSP-1 indicates that both periods saw intensive use of the area, whereas during the middle Holocene it was all but abandoned. Radiocarbon dates from LSP-1 paint a similar picture (see Table 1): there was an initial pulse of activity at the site during the terminal early Holocene. After a prolonged break in occupation during the middle Holocene, groups returned to LSP-1 and occupied it episodically throughout the late Holocene. These periods of elevated population levels in northern Warner Valley are precisely the conditions under which nutritional ecology predicts high nutritional diversity.

## 6. Conclusions

Nutritional ecology offers an alternative to models derived from HBE for researchers interested in reconstructing prehistoric diet and understanding hunter-gatherer decision-making. In this paper, we presented the results of the analysis of macrobotanical remains from a stratigraphic column sample and nine hearth features spanning more than 9000 years at the LSP-1 rockshelter in northern Warner Valley. A previous analysis of a sample of fauna from the site indicates that groups field-processed large quantities of leporids, which were probably mass harvested nearby during the fall or winter seasons (Pellegriani, 2014). Today, jackrabbits and cottontails are abundant in the valley and this was apparently the case in the past as well. These animals represented a predictable resource that, when mass harvested, may violate assumptions of the prey choice model related to body size and return rates (Jones, 2006; Simms, 1987, but see Ugan, 2005). Additionally, they provide critical raw materials for clothing production (Fowler, 1992). When viewed from an HBE perspective, the faunal assemblage from LSP-1 suggests that life was good and that the occupants of the site should not necessarily have elected to process lower-ranked plant resources. But they did, as evidenced by the abundant ground stone

**Table 4**  
Comparison of macro- and micronutrients of wild foods at LSP-1 (value per 100 g).

Nutrient	Unit	Resource					
		Wild rabbit	Chenopod	Cattail	Mustard greens	Chokecherry	Currant
Water	g	74.51	84.3	92.65	90.7	61.5	83.95
Energy	kcal	114	43	25	27	156	56
Protein	g	21.79	4.2	1.18	2.86	2.89	1.4
Total lipid (fat)	g	2.32	0.8	0	0.42	0.98	0.2
Carbohydrate, by difference	g	0	7.3	5.14	4.67	33.88	13.8
Fiber, total dietary	g	0	4	4.5	3.2	17	4.3
Sugars, total	g	0	0	0.22	1.32	14.22	7.37
Minerals							
Calcium, Ca	mg	12	309	54	115	40	33
Iron, Fe	mg	3.2	1.2	0.91	1.64	0.4	1
Magnesium, Mg	mg	29	34	63	32	21	13
Phosphorus, P	mg	226	72	45	58	45	44
Potassium, K	mg	378	452	309	384	309	275
Sodium, Na	mg	50	43	109	20	2	1
Zinc, Zn	mg	0	0.4	0.2	0.3	0.2	0.2
Vitamins							
Vitamin C, total ascorbic acid	mg	0	80	0.7	70	0.7	41
Thiamin	mg	<0.01	0.16	0.023	0.08	0.029	0.04
Riboflavin	mg	0.06	0.44	0.025	0.11	0.058	0.05
Niacin	mg	6.5	1.2	0.44	0.8	0.672	0.1
Vitamin B-6	mg	0	0.274	0.123	0.18	0.193	0.07
Folate, DFE	µg	0	30	0	12	10	8
Vitamin B-12	µg	0	0	0	0	0	0
Vitamin A, RAE	µg	0	580	1	151	2	2
Vitamin A, IU	IU	0	11,600	11	3024	43	42
Vitamin E (alpha-tocopherol)	mg	0	0	0	2.01	0.75	0.1
Vitamin D (D2 + D3)	µg	0	0	0	0	0	0
Vitamin D	IU	0	0	0	0	0	0
Vitamin K (phylloquinone)	µg	0	0	22.8	257.5	29.3	11
Lipids							
Fatty acids, total saturated	g	0.69	0.059	0	0.01	0	0.017
Fatty acids, total monounsaturated	g	0.63	0.15	0	0.092	0	0.028
Fatty acids, total polyunsaturated	g	0.45	0.351	0	0.038	0	0.088
Cholesterol	mg	81	0	0	0	0	0

Source: USDA National Nutrient Database for Standard Reference 27 Software v.2.2.6 (USDA, 2015).

artifacts and high volume of charred seeds at the site. Visitors to LSP-1 procured, processed, and consumed large and diverse quantities of plant resources within the context of elevated population levels in Warner Valley and the northern Great Basin as a whole. Our findings correspond well with the prediction of the nutritional ecology model that diverse subsistence residues should mark periods of demographic expansion and overall good dietary health. They also offer additional understanding of hunter-gatherer life in the northern Great Basin during the Holocene and suggest that groups' subsistence pursuits may not have been driven exclusively by caloric concerns.

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