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BALANOPHAGY IN THE PACIFIC NORTHWEST: THE ACORN-LEACHING PITS AT THE SUNKEN VILLAGE WETSITE

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ABSTRACT

Archaeological and ethnographic studies in North America have recorded the importance of acorns where they were available to many cultures through resource or trade, but they have not generally been considered an important plant resource in the Northwest. Recent archaeological examination of approximately one hundred acorn-leaching pits on Sauvie Island, Oregon suggests otherwise. Comparison of the Oregon white oak range with ethnographic and archaeological information indicates that acorns were consumed in the oak's range through western Washington, continuing south into the well-documented California acorn cultures.

Introduction

Test excavations of the National Historic Landmark Site 35-MU-4, the "Sunken Village," have revealed the remnants of over one hundred pit features constructed by Chinookan people on a muddy slough of the Multnomah Channel on Sauvie Island, Oregon. The "Sunken Village was known by generations of artifact collectors and archaeologists for the basketry and other perishable objects found within the aquifer that has preserved these artifacts and features over hundreds of years. Archaeologists have previously identified the site as an acorn storage or processing facility (Newman-Zehendner 1992), which is a well-represented feature in California archaeology, but nearly absent on the Northwest Coast (cf., Ames 1999:43). The abundant pit features on Sauvie Island are evidence of the use of a plant resource that has likely been underestimated on the Northwest Coast in general, and a reminder of the elaborate trade systems of the Lower Columbia region.

Pacific Northwest Balanophagy

The Oregon white oak (*Quercus garryana*) inhabits the west coast from northeastern Vancouver Island in British Columbia to Los Angeles, California, extending eastward over the Cascade Mountains along the Columbia River (Peter and Harrington 2002:189). It is the only oak native to British Columbia and Washington, and dominates the oak populations of Oregon (Agee 1993:352; Stein 1990:650-651). In California, however, it is one of many nut-bearing trees (most from the genus *Quercus*) which populations utilized for generations as a dietary staple. Balanophagy, the "eating of acorns," is described ethnographically as a unifying characteristic of California cultures (Gifford 1971:301), owing to the abundance of species throughout that region and the development of complex processing and storing techniques. Through living memory, ethnography and archaeology, the process of gathering and preparing acorns is recognized as a vital piece of culture and livelihood for thousands of years in that region.

The typical process of preparing acorns in California, as followed by the Yosemite Miwok/Paiute tradition, involves gathering, drying, shelling, winnowing, and pounding the acorns into flour, followed by leaching the acorn flour with water to remove bitter tannins (Ortiz 1991). Though removing the astringent tannic acid is not necessary when eating acorns in small servings, the leaching process sweetens the acorns, and this would be necessary when consuming varieties other than the white oak, as they have significantly higher concentrations of tannic acid. Leached acorn flour was then prepared as cakes, breads, and porridges (Moerman 2002:461). Though southern California leaching methods are always described as an active process, passive leaching (called such because it is much less labor intensive than the "active" California method) has been recorded in northern California, where the white oak is the dominant oak type. For instance, the Wintu of northwest California leached acorns in swampy grounds through the winter, then removed them in the spring and prepared them by boiling or roasting (Moerman 2002:459). A passive leaching pit site north of San Francisco, dated to between 3370 and 4450 BP, suggests that passive leaching was a technique used in central California before active leaching techniques were widely adopted around 3000 years ago (Eric Wohlgemuth 2008, pers. comm.).

Discussions of the acorn in diets of Northwest Coast peoples range from dismissive (e.g. Gifford 1971:301) to locally limited (e.g. Ames and Maschner 1999:120). On the Northwest Coast the passive leaching method is the only leaching process noted in the few ethnographies that describe leaching, so it seems unlikely that the California acorn flour leaching technique was used much, or at all, to the north. Groups like the Chehalis and Cowlitz of present-day southwestern Washington (Moerman 2002:461; Gunther 1973:28) were noted to have used the passive method, while preparations further north required less processing time, potentially suggesting less of an economic investment. For example the S'Klallam, whose ancestral homeland is encompassed by northwestern Washington, and the Nisqually of the Puget Sound ate acorns with no preparation (raw). The Squaxin of the southern Puget Sound area roasted them on hot rocks before eating (Gunther 1973:28; Moerman 2002:461). This information appears to suggest some importance, but not nearly the same investment as California balanophagy. However, the minimal *comparative* investment should not be confused with local significance. While some of these processing techniques required relatively little investment, the Snohomish and Suquamish are noted to have travelled to the Nisqually valley and camped from August to September to gather acorns and berries, as did people from as far away as the Strait of Juan de Fuca (Norton 1979:187), which suggests considerable energy investment. Additionally, these brief mentions in the ethnographic record have, in one instance other than the Sunken Village excavation, been found to correlate with a high proportion of acorns in the archaeological record. Acorn shell fragments

have been excavated in large quantities at *Q^{w}u?g^{w}əs* (45-TN-240), a Squaxin shellfish processing site near Olympia, WA, where acorns greatly outnumber other midden plant food remnants (personal observation 2008). It is unlikely that these are the remnants of rare instances of use which by chance were preserved in a waterlogged environment. The presence of this resource at these sites suggests that acorns were more ubiquitous in middens throughout the Northwest.

Ethnographic and other historic information from the Columbia River area indicate acorns were also a trade resource. Lewis and Clark mentioned that people living near the river, probably the Wishram, said they acquired acorns from people at the Dalles (DeVoto 1997:259). The Wascopam of The Dalles baked acorns in the earth with hot rocks, and then leached them in pits dug near water through the winter. In the spring women were seen on a stream bank, removing acorns from the water. Their acorns were eaten with dried or pounded salmon (Aguilar 2005:77-78).

The Wascopam and Chinook story of Little Raccoon and his grandmother add further strength to ethnographic information. This story about a greedy young raccoon describes five pits of acorns being stored by his grandmother for the winter. Little Raccoon is tired of eating wapato, jerky, and dried fish-eyes, so he sneaks acorns from the acorn pits and in both versions of the story proceeds to get himself into a lot of trouble with grandmother, transforming himself and his grandmother Blue Jay into their current forms. In the Chinook version of the story, grandmother stores her acorns in swampy ground, much like that of the Sunken Village. In fact, the few ethnographic accounts that mention leaching pits frequently mention that the pits are excavated into blue soils, suggesting pits were often located in aquifer locations. (Hunn 1990:186-187; Ray 1938:148-151).

In 1847 Paul Kane, an artist and explorer, recorded that acorns were prepared as a delicacy by Chinook, in a way that was "a peculiarly characteristic trait of the Chinook Indian… confined solely to this tribe." According to Kane the preparation, called "Chinook olives" by European explorers, was made by digging a hole in the ground close to the entrance of a house, filling it with a bushel of acorns, then covering the hole with grass and dirt, and depositing urine in the hole for four to five months. Kane writes that the Chinook considered these acorns "the greatest of all delicacies" (Harper 1971:94). Removing tannins with urine would speed up the neutralization of the acids, but would probably require a much more complicated leaching process than that of waterlogged pits. This method could indeed have produced a truly rare and coveted delicacy, but I have argued against the validity of Paul Kane's account from an ethnohistoric perspective (Mathews 2008). Interestingly, a recent recording of a Klamath story to the south substitutes urination for passive leaching as well (Friday 2003:113), but this account, like many others in the decades following Kane's publication, appears to be relying on the above historic description.

It should be noted that while the archaeology and combined ethnographic information discussed in this paper appear to be rediscovering this resource's significance to the Northwest Coast, Chinookan descendant communities actively honor this knowledge in their inherited traditions. Through the tumultuous contact period, the history of acorn gathering is preserved in the Chinuk Wawa (Chinook Jargon) word for acorn, *k'ánawi təqwəla* (Eirik Thorsgard 2008, pers. comm.). The Athabaskan word *tus-xa* is used by the Confederated Tribes of Siletz Indians to refer to acorns that are leached in stream banks for several months to a year, and acorns are still gathered, stored and eaten by people there (Bud Lane 2007, pers. comm.).

Defining 35-MU-4's Acorn-Leaching Pits

During the limited excavation (2006) and mapping (2007) approximately 100 pit features were recorded in a 125-meter section of the Multnomah Channel slough. These remnant features contained basketry, lithics, wood, bone, and botanical artifacts, which are all believed to be associated with the function of the pit features, or as a result of activity at the site during resource guarding. Beyond examining the surface of the pits at 35-MU-4, one pit feature (Pit P, Transect VI) was completely excavated in 2006 so that a profile could be studied. Many others were sampled, but none offered the same depth of preservation.

The pits recorded at 35-MU-4 were identified on the surface, sometimes because of the presence of acorns, but the more obvious marker of the leaching pits at the surface is a circle of branches protruding from the beach (Fig. 1). Fire-cracked rock, found throughout the surface of the slough, tends to settle on pit depressions and was also used as an indicator, though circular formations of fire-cracked rock proved to be misleading at times. Associated with the pits were over forty wooden stakes, which may have served as markers for the pits on the beach surface, either for identification on the slough after silting, or for ownership purposes (Fig. 2).

Acorns

Acorns are the most abundant botanical artifact associated with the pit features, and were identified as those of *Quercus garryana*, commonly called Oregon white oak (Fig. 3 and 4). For comparison, some contemporary acorns were collected from trees growing on Sauvie Island, which were identified by leaf as the Oregon white oak (Pojar 1994:50). Girth measurements of a few large trees about a mile from the site estimate that a dense oak population has been available nearby for over 700 years (personal observation).

Acorns at Sauvie Island were found complete, or in fragmented parts of the shell and nut. Though a large percent of the acorns were only found in fragments (73%), the fragments generally represent all parts of the acorn. Acorn caps, with three exceptions, were not found in the pits. Although they would have preserved as well or better than the thinner acorn shell in the archaeological record, acorns with caps attached probably would not have been collected, as these would be infested and are known to fall from the tree not because of ripeness but from insect movement. Many acorns were whole (with the nut inside the shell) which means they were being left in these pits on the beach for later use instead of immediate consumption, unlike the numerous hazelnut fragments which appear to have been processed and possibly eaten at the site.

A small portion of the acorn fragments were found completely charred, while most fragments and whole acorns show some mottled marks that appear to be the result of heat, but might also result in part from the leaching process. Cooking the acorns could have killed any insects that had already infested the nuts, and could also have been a means to add flavor. Heating could also have split the shells open, which has been proven to be very beneficial to the rate at which the tannins are leached out (personal observation). Heating would also prevent the acorns from germinating during the storage period, and as Oregon white oak acorns germinate very soon after ripening, this process would avoid the loss of nutrients that would follow germination.

Fig. 1. Branches protruding from pit base, before fire-cracked rock or silt is removed.

Fig. 2. A well-preserved wooden stake with intact bark.

Western Hemlock

Twigs protruding from the ground marked pits in a circular pattern on the surface, and the pits were lined from the sides to the base of the pit. Many of the twigs and branches, especially those at lower, less disturbed levels, still had needles attached (Fig. 5). Branches lining the bottom of Pit P (Transect VI) were radiocarbon dated at 1760 to 1880 CE (130 ± 60 BP) (Fig. 6). The intact needles made it possible to identify the species, but wood cells identification confirmed the species was western hemlock (*Tsuga heterophylla*) (Croes et al 2009:78), which grows along the coastal areas of Oregon, Washington, and British Columbia (Pojar 1994:30). It may be that this type of branch was selected over other conifers, as the boughs are flat and dense. This would allow water to pass through easily, but protect the store from the mess of the surrounding matrix. Hemlock was also considered an edible plant by many tribes of the Pacific Northwest, which might have led to it being chosen over other conifers (Moerman 2002:571).

Charcoal

Charcoal is found throughout the site at every level of excavation in pit features. Over 5000 thumb-sized or larger pieces were collected from 35-MU-4, with 2500 coming from the half-excavated Pit P. Though charcoal could be the remnants of cooking or wood burning done at or near the site, ash and charcoal are frequently used in leaching processes in California (Gifford 1971:301). As ash speeds up the leaching process, adding oven or hearth remnants to the pits would ensure that the acorns were sweetened by the time they needed to be removed from the pits.

Pit Construction

Pits generally take on a circular shape at the surface, with diameters smaller than a meter. While only a few pits were tested, the depth of a well-preserved pit (Pit P, Transect VI) was 55 cm below the surface. Many pits were badly eroded with only a few centimeters of depth remaining. The acorn-leaching pits are concentrated in a 125-m section of the slough (Fig. 7), where aquifers under the natural levee would have moved water through the buried acorns. The rising water of the Multnomah Channel would have covered the sealed pits after harvest in the fall until early spring (Croes et al 2009:31). This compares well with ethnographic reports of acorns leaching for several months after harvest. None of the features at 35-MU-4 were intact enough to contain a seal, but it is likely that the pits would have needed to be covered with soil or branches and fire-cracked rock to prevent acorns from floating away in the channel's waters before they became heavy with saturation.

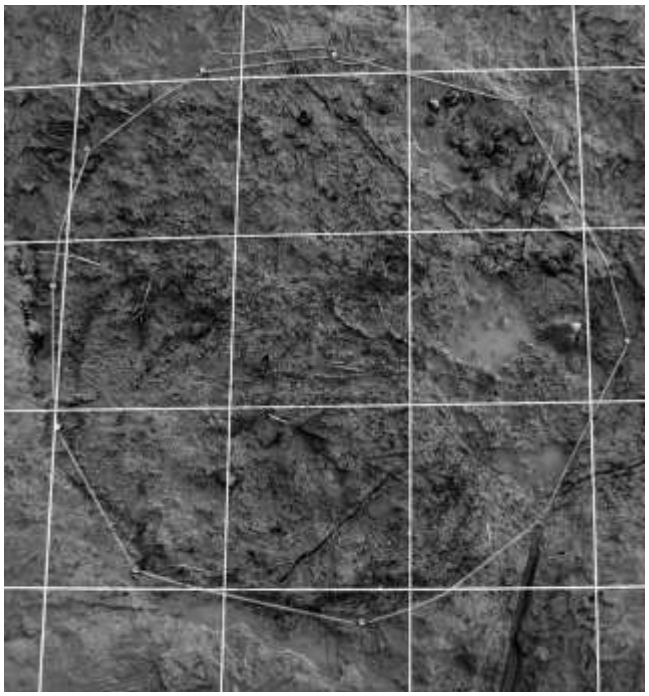

Fig. 3. Example of acorn-leaching pit (Pit A, Transect IV) after silt layer is removed.

Fig. 4. Close-up of Fig. 3 showing acorns, hemlock boughs with needles intact and anaerobic soil.

Fig. 5. In situ hemlock branches and needles near the base of a pit, after silted surface has been washed. Acorns and hazelnuts can be seen in this photo (bottom and top respectively).

Fig. 6. Base of north half of Pit P excavation, exposing the hemlock lining, which ^{14}C dated to 1760 to 1880 CE (130±60), indicating the last time this pit was used.

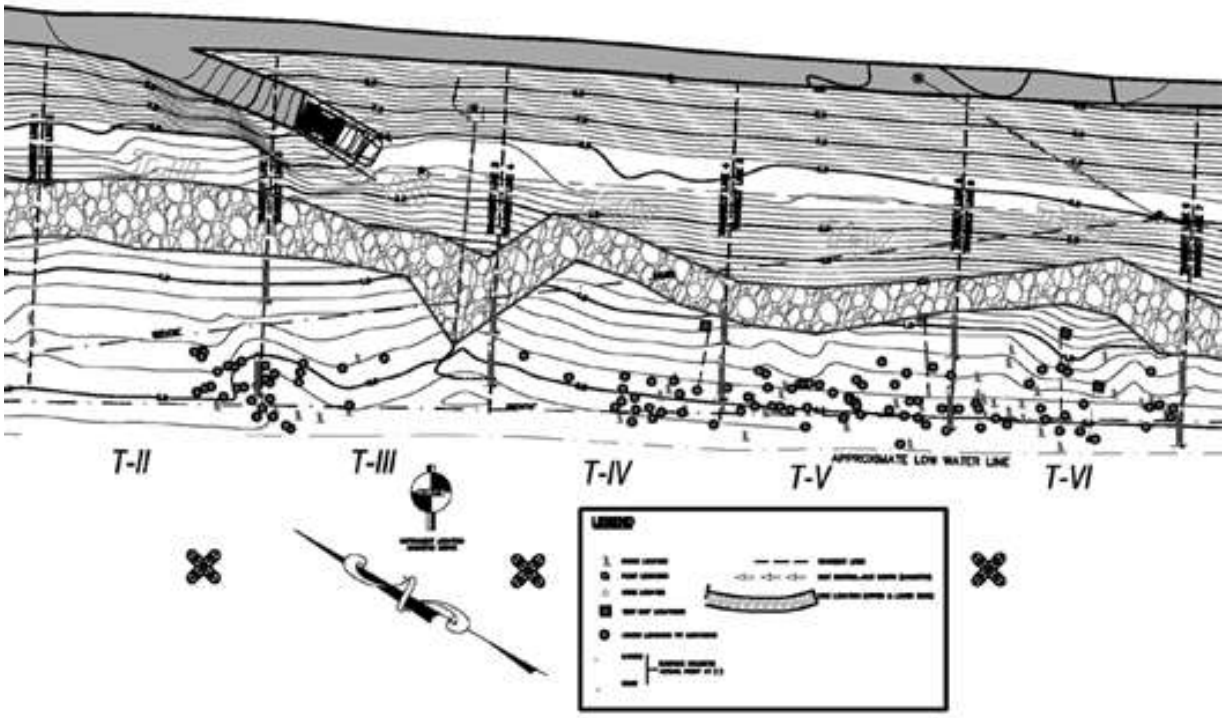

Fig. 7. Map of site from water. "T" marks 25-m transects. The circle figures are pits. Notice the gap in T-III, which was previously excavated for agricultural drainage (Created by Michael Martin, SPSCC).

Population Estimate

An estimate of the possible human population supported by the acorn-leaching pits on Sauvie Island was made by determining the size of the individual pits, how many acorns they might store, and how many people could be fed by the estimated total of acorns present. Estimates were then compared to historical statistics on populations living near the site of the leaching pits at approximately their time of use, and to California ethnographic information on populations that relied on acorns as a staple food. It should be noted that these figures are nowhere near as exact as the incredible quantitative research completed by Sakaguchi (2009) on Jomon storage facilities in Japan, but these estimates serve as an approximation for understanding the magnitude of this resource.

Acorn-Leaching Pit Volume

The volume of the leaching pits was calculated using Pit P in Transect VI as a model. Pit P was a well-preserved pit and is probably representative of the size of the ancient leaching pits, but could potentially represent several pit digging episodes (Fig. 8). This feature was first

measured at the surface, and then a 1 x 1.5 m unit was excavated so that a profile of the pit could be seen. The general shape of the pit can be described as a half-sphere at the bottom, with a cylinder extending the pit to the surface. A formula for the volume of this shape was created by adding these shapes together. The formula for the volume of a cylinder and half sphere is $V = \pi r^2 h + \frac{2}{3} \pi r^3$ (based on volume formulas in Percy 1997:107, 409). The surface of Pit P was 84 cm at the widest, and 71 cm at the narrowest area of the pit, which is closely comparable to the average recorded pit surface measuring 82 centimeters by 72 cm. For the purpose of making a conservative estimate, the narrowest diameter of 71 cm was used to calculate the volume of Pit P. Though the cap of the pit has probably eroded to some degree, the bottom of the feature is marked by hemlock boughs lining the pit at 55 cm below surface. This means that the pit originally extended at least 19.5 cm above the half sphere shape. Plugging these numbers into the volume formulas for the pit shape, the total volume of Pit P is found to be about 170,900cm^3.

Ancient Quercus garryana Acorn Volume

Similarly, the general shape of the average acorn found at 35-MU-4 is that of a divided sphere joined by a cylinder of the same diameter. The formula for this volume is $V = \pi r^2 h + 4/3 \pi r^3$ based on volume formulas in Percy (1997:107, 409). The average size of acorns leaching at Sauvie Island was found by measuring the length and width of excavated whole acorns. Sixty examples were used to find the average size, which at present is believed to be 2.218 cm long, and 1.610 cm wide. Like the pit volume calculations, these numbers were used in the volume formula and the volume of the average acorn is believed to be about 3.423 cm^3.

Acorns per Acorn-Leaching Pit

To estimate how many acorns each pit is capable of holding, the pit volume is divided by the volume of the average acorn. An estimate of volume displacement had to be made to account for the space being displaced by the acorns. Using one liter of Oregon white oak acorns, displacement was found to be about 40%. The volume occupied by the acorns when pits were full would be about 102,540 cm^3, meaning that nearly 30,000 average acorns could fit into each pit. The displacement calculation also showed that 120 acorns fit into a one liter container, meaning that about 20,500 might fit into a pit. The rest of the calculations will use 25,000 as an average of the two.

Acorn Totals at 35-MU-4

Using the estimate of 25,000 acorns per pit, and a minimum of 100 pits, there may have been approximately 2,500,000 acorns being processed at the site every winter, if these pits were filled annually. Aside from the uncertainty of consistency of original pit sizes and the possibility of ash or other fill, the biggest potential problem with this figure may be that pits seem to overlap in places and may not have all been used contemporaneously. However, as far as possible at present, these estimates are conservative. Further research

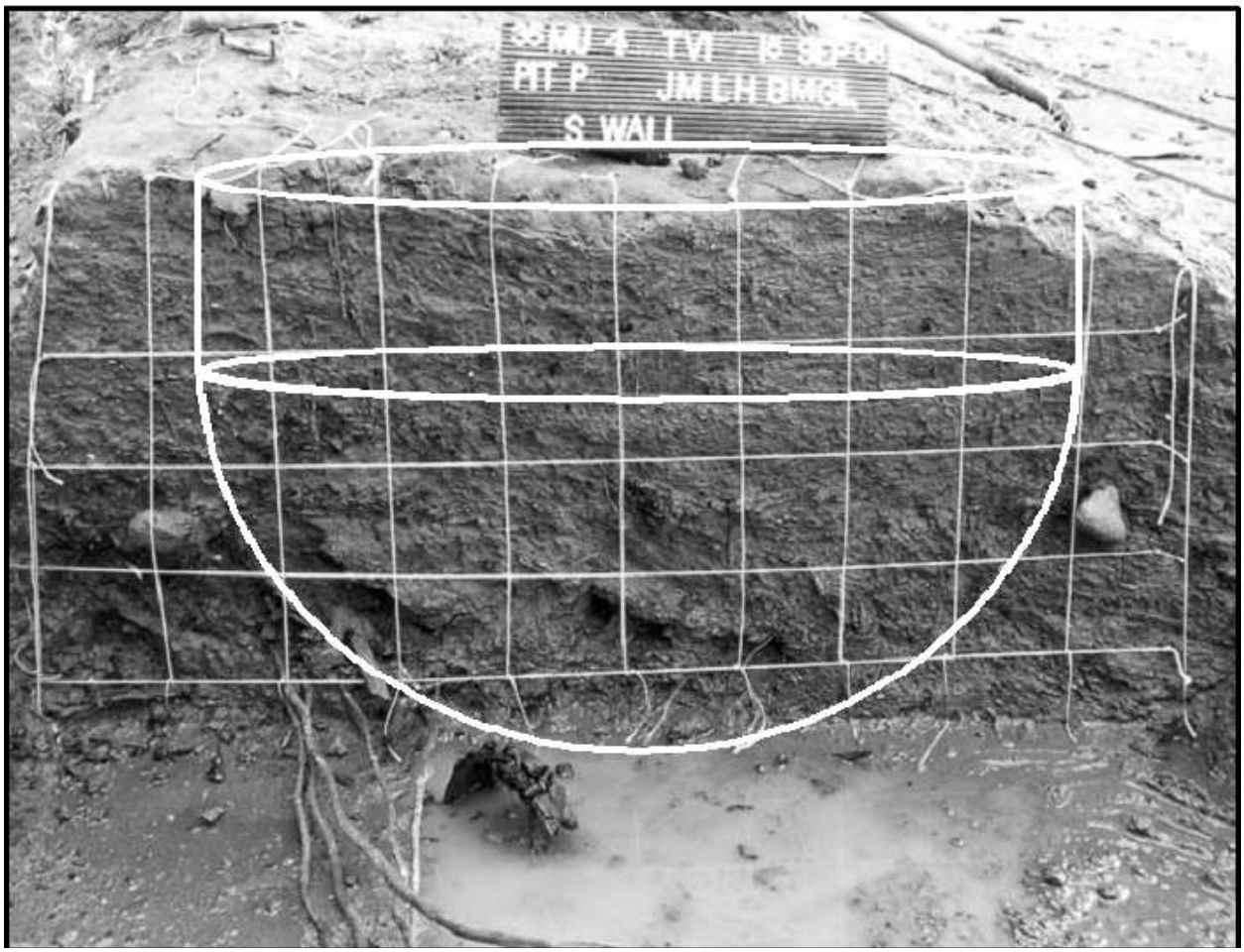

Fig. 8. The volume of the leaching pits was calculated using Pit P in Transect VI as a model. Note the hemlock bough lining and rocks along outer edges. The diagram approximates the extent of the pit.

may result in identifying more leaching pits, so I believe it is reasonable to assume that these one hundred or more pits might have been used at the same time.

Large crops are produced every three years on the Oregon white oak, followed by a year of moderate production, and a year of crop failure before the bumper crop year returns (Peter and Harrington 2002:198). Approximately 325,000 acorns can be collected from a hectare of oak grove in the Willamette Valley (south of Sauvie Island), which means that less than 8 ha of oak would have to be collected from to fill these pits during bumper years. A study showed that Oregon white oaks in the Willamette Valley can produce up to 1737 kg of acorns per ha (Stein 1990:1267). The average mature acorn from *Q. garryana* weighs 5.35 gms (Young 1992:292) meaning that about 325,000 acorns can be collected from a hectare of Oregon white oak grove. If the acorns were collected during a moderate production year, it seems likely that the trees needed to fill the leaching pits would be available, given the proximity of oaks today. During a crop failure year, it could be that few pits were utilized on the Multnomah slough.

Acorn Nutrition

To calculate the amount of calories these acorn-filled pits could provide a population, the calories per acorn were multiplied by the possible total amount of acorns. Using the estimate of 4.44 calories per gram, each *Q. garryana* acorn contains about 23.75 calories when consumed raw. Based on data in Young 1992, the average mature acorn from *Q. garryana* weighs 5.35 gms. Though I have not located data for the calories per acorn, other important nutritional values are comparable to the acorns from *Q. lobata,* another white oak, which grow in regions of California with *Q. garryana. Quercus lobata* contains 4.44 calories per gram (Bainbridge 1986; Basgall 1987:25). If the site has 2.5 million acorns leaching for use every year, the Sunken Village pits could have provided over 59 million calories to the group or groups who owned them. About 70% of the Oregon white oak acorn's nutrition is in the form of carbohydrates (Bainbridge 1986), which people in the area might have had a great need for it in the winter or early spring months when the acorns could have been retrieved from pits after leaching.

Possible Population

To understand how many people this calorie figure is capable of supporting, the Mono of California, who represent a maximum of dependence on this food, can be looked to as a model for a minimum population. A group that had 2.5 million acorns available could support 175 individuals who consumed 39 acorns a day for 365.25 days, the equivalent of the Mono staple preparation. According to information in McCarthy 1993, the Mono consumed a preparation of acorns that required as many as 207gms of whole raw acorns a day per person, the equivalent of about 39 *Q. garryana* acorns a day. Consuming 39 acorns a day for 365.25 days would mean that every individual would consume nearly 14,250 acorns annually. A society that had 2,500,000 acorns available, and depended on acorns as a staple food, would at minimum support 175 individuals.

Since we can assume that acorns on Sauvie Island were not relied on for as great a portion of diet as they were in California, the millions of acorns leaching on Sauvie Island would have supported a larger population throughout the year. If acorns supplied only 500 calories to a person per day, the population supported might number over 300 individuals. If the acorns represent a smaller portion of the diet, as is suggested with the "Chinook olives" idea of delicacy, the population estimate grows to such a large number that trade to other communities would have been likely to make use of the acorns throughout the year.

It is interesting to compare these population estimates to the 1805–1806 Lewis and Clark statistics for the area, which recorded populations varying seasonally, increasing in the spring when more resources were available on the rivers than in the outlying areas. For the Multnomah Channel this meant that populations increased from 420 individuals in the fall of 1805, to 970 in the spring of 1806. Along the lower Columbia River, Lewis and Clark statistics nearly doubled from 9800 in the fall, to 17840 in the spring (Boyd 1987:313). This seasonal population increase could coincide with the time when waters on the slough would have receded, and acorns might have been retrieved to support a population that was coming to the area for foods before spring produced abundant resources in their area.

Conclusions

Historic, ethnographic and archaeological information support the idea that acorns were used as a source of food by people throughout what is now Oregon and Washington prior to European contact. If acorns were not a significant source of nutrition throughout the year, they were at least important seasonally for many groups, and especially for those with access to prairie landscapes. Tribes traveling long distances, camping and trading for acorns demonstrate that this food source was considered to be worth the energy it required to obtain and process it. Observations of passive leaching methods in the Northwest at contact and ethnographic descriptions are fairly wide-spread, though rare. Future understanding of the extent and antiquity of these passive leaching features in the Northwest might explain whether there was a migration of the idea through the northwest to California or vice versa, where the same species of oak is used.

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