Exploring Prehistoric Salmon Subsistence in the Willamette Valley using Zooarchaeological Records and Optimal Foraging Theory

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by

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Abstract

My research examines the prehistoric subsistence of native peoples of the Willamette Valley, Oregon through an analysis of the regional zooarchaeological records, and then modeling regional diet breadth. Through this analysis, I challenge commonly held stereotypes that the indigenous people of the Willamette Valley were strictly root eaters, and the basis for this claim, that salmon were not part of Native subsistence. The results of my research indicate that given the incomplete nature of the ethnohistoric record, very little can be said about expected cultural behaviors, such as salmon consumption, that appear to be absent in the Willamette Valley. In addition, since the faunal assemblage is so small in the Willamette Valley, zooarchaeological data are simply inadequate for studying the relationship between prehistoric peoples and their animal resources. Finally, optimal foraging modeling suggests that salmon is one of the higher ranked resources available to the Native People of the Willamette Valley.

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Chapter 1. Introduction

My research examines the prehistoric subsistence of native peoples of the Willamette Valley, Oregon through an analysis of the regional zooarchaeological records, and then modeling regional diet breadth. I intend to assess whether there is evidence for salmon consumption using the Willamette Valley archaeological record, and whether salmon (*Oncorhynchus* spp.) would have been a viable resource for exploitation.

Regional anthropological and archaeological literature tends to characterize the people of the Willamette region as "root eaters" or people that depended primarily on plant resources for subsistence. This belief is based on ethnohistoric and archaeological evidence of extensive plant exploitation in the valley (Coues 1897, Aikens 1993), and is further supported by sparse ethnohistoric evidence highlighting salmon use and the apparent absence of salmon remains in the archaeological record (Zenk 1990, Aikens 1993). It is also possible that archaeological overviews and ethnographic accounts of regional subsistence have been colored by the misconception that salmon could not ascend Willamette Falls (McKinney 1984:23). For example, in an archaeological overview, Beckham et al. (1986: 2) states that "no salmon spawned up the stream in the Upper Willamette". If true, this apparent exclusive reliance on plant foods would differ greatly from the commonly noted subsistence practices of the larger Pacific Northwest region, where anthropologists have viewed salmon as central to Native American diet (Schalk 1986:2).

However, there has been no systematic analysis of the zooarchaeological record from the Willamette Valley to substantiate the view that salmon was not exploited. To address this issue, I systematically overview and synthesize existing zooarchaeological records in the Willamette drainage to better understand the role or lack of role that salmon played in the subsistence practices of native peoples in the Willamette Valley. In doing this, I will ascertain whether the regional archaeological record is adequate for assessing salmon use in the Willamette drainage. If the regional archaeological record is adequate for analysis, then I will examine the extent to which people of this region exploited salmon. If the archaeological record supports the view that salmon were not exploited in the Willamette Valley, then this raises questions about why this resource was not used. For example, were salmon runs too unpredictable, did the timing of the appearance of this resource coincide with a more favored resource, and/or were salmon only able to ascend the falls in the very recent past? To address questions such as these, I will use the diet breadth model to test whether salmon exploitation would have been a viable option for the people of the Willamette Valley given the availability of a variety of resources. If the diet breadth analysis predicts that salmon should have been exploited, I will analyze whether other factors, such as an abundance of higher ranked resources, lowers the relative rank of salmon.

This thesis is organized into five chapters. Chapter 2 provides background on various components, including salmon abundance, and distribution above Willamette Falls, the regional ethnographic record, the existing archaeological record, and factors that affect faunal representation in the archaeological record. Chapter 3 presents the methods and results from analysis of the faunal records in the Willamette Valley. In chapter 4, I use diet breadth analysis to determine whether salmon should have been used by native peoples of the Willamette Valley, as well as analyze whether there were mitigating factors that affected the relative rank of salmon. Finally, chapter 5 summarize conclusions derived from the results and discuss the broader implications of my study.

Chapter 2: Background

Willamette Valley Physiography

The Willamette Valley is a broad, north-south oriented drainage, located between the Coast Range to the west, and the Cascade Range to the east (Figure 1). The volcanic Cascade Range consists of uplifted Columbia River basalts, deposited in the Miocene. The Coast Range was formed through the development of volcanic islands at a eugeosyncline west of the ancestral Cascade Range (Glenn 1965). The valley extends 125 miles south to north, and is between 20 and 30 miles wide, east to west. Broad alluvial flats, low hills, and a very gentle north-facing slope characterize the valley floor (Franklin and Dyrness 1979:15). As a result of this very gentle slope, the river is slow, and has many meanders. The valley floor consists of deep (as much as 500 m) lacustrine and fluvial fill with between 10 and 50 m of quaternary sands and gravels at the surface (O'Connor et al. 2001), while the valley borders consist of various sedimentary and igneous rocks (Franklin and Dyrness 1979:15).

The northern end of the Willamette Valley has a single large, horseshoe shaped, block waterfall, which incises a gorge through tertiary basalt between Oregon City and West Linn (Figure 1). This falls, known as Willamette Falls, is approximately 12 m tall (Alt and Hyndman 1981, Wallick et al 2007), though given major developments over the last 150 years, it is difficult to know the pre-development configuration. The actual distance between the surface of the river above and below the falls varies depending on river flow rate and tidal force

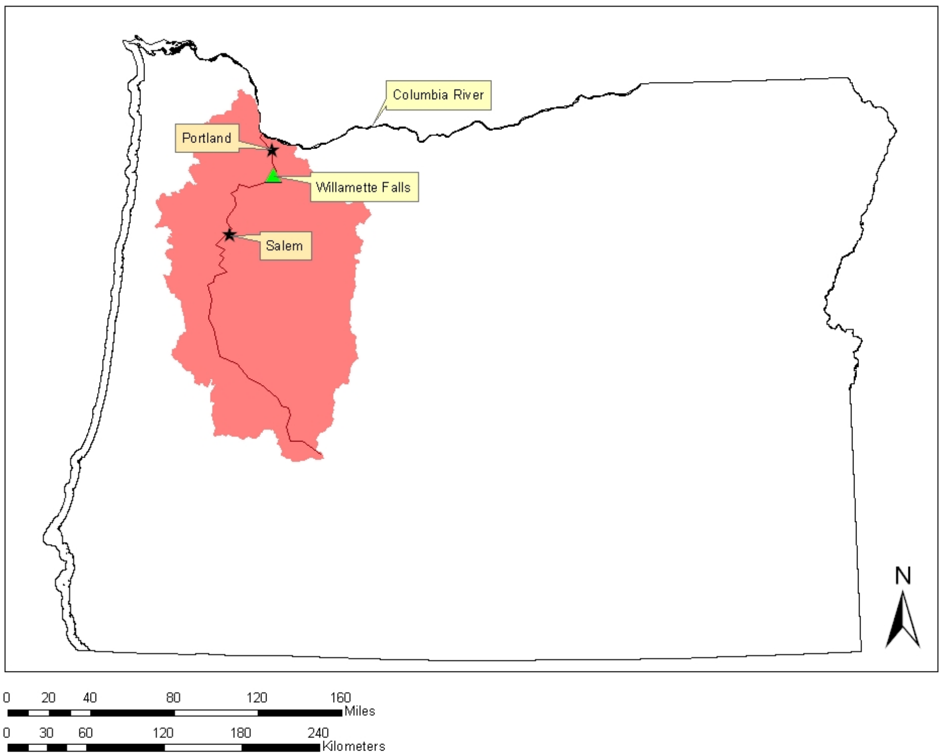

Figure 1. The Willamette Valley Watershed

Three rivers, including the Coast Fork, Middle Fork and North Fork Willamette, which originate in the mountains south of Eugene, make up the headwaters of the Willamette River. There are nine main tributaries of the Willamette River. The McKenzie, Calapooia, North and South Santiam, Molalla, and Clackamas rivers have their headwaters in the Cascade Mountains, while the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin rivers have their headwaters in the Coast Range mountains.

The vegetation communities located in the Willamette Valley include Oak (*Quercus*) woodlands, coniferous forests, and grasslands, the distribution of which has been affected by human activities (Franklin and Dyrness 1979: 110). The region is warmer and drier than any other region west of the Cascades in Oregon, primarily a result of the rain shadow of the Coast Range to the west. In addition, precipitation generally decreases as one moves east from the Coast Range towards the Cascades. Precipitation decreases slightly as one moves north from the headwaters of the Willamette to it's mouth. For example, Salem, OR., in the northern portion of the Willamette Valley gets around 1050 mm (41 inches) of rain per year, while Cottage Grove, OR., located at the southern portion of the Willamette Valley, gets around 1168 mm (46 inches) of rain per year. Mean annual temperature slightly increases as one moves south from the mouth of the Willamette River to its headwaters (51 degrees F in Salem, OR. 52 degrees in Medford, OR.) (Franklin and Dyrness 1979: 110-111).

Salmon above Willamette Falls

The geomorphology of the Willamette River system has been used to argue that migrating salmon were blocked by Willamette Falls. Cheatham (1988:199) writes:

> The lava flow that underlies the Willamette River near Oregon City stands in a special relationship to prehistoric cultural development in the Upper Willamette valley, for the Waterfall it created there presented an almost insurmountable barrier to anadromous fish attempting to migrate upstream. The result was that salmon constituted at best an undependable subsistence resource for the prehistoric peoples who lived upriver. The lava sill also prevented the river from increasing its slope, resulting in the maintenance of a broad, moist valley flood plain in the Upper Willamette Valley, an ideal setting for abundant propagation of the camas lily. In effect, the falls denied Willamette Valley Natives the use of salmon, a major subsistence resource throughout the Northwest Coast and Plateau, while significantly increasing the availability of camas, a secondary staple elsewhere.

The example above attempts to explain, through conjecture based upon regional geomorphology, why salmon were not used by the Native people of the Willamette Valley. However, this explanation does not adequately account for two realities. The first is that both biological (Fulton 1968, 1970, Quinn 2005: 323) and ethnohistorical evidence (see below) show that Willamette Falls did not form a permanent impassible barrier to fish migration. Fulton (1968:4-7; 1970: 5) notes, based on a regional fish inventory, that anadromous salmonids, including steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) spawn in the upper Willamette River and its tributaries while coho salmon (*Oncorhynchus kisutch*) were introduced historically (Fulton 1970: 15-17). The second, which I will address through my research, is that zooarchaeological records have not been sufficiently examined to substantiate the claim that salmon were not used by the Native people of the Willamette Valley.

Several factors, including geomorphology and climate patterns, may have limited salmon passage historically and in the more ancient past. Schalk (1986:13) suggests that seasonal variations in river height and waterfall volume affected the vertical distance that the fish need to jump to ascend the falls. During periods where a high volume of water is expelled over the waterfall and the river is high (after spring snow melt and in early summer), the vertical distance may be half that of the falls during the dry season, which extends between July and October (Zenk 1976). As a result, fish may only have been able to ascend the falls in the spring and summer. This also suggests that in years with decreased precipitation or limited snow-pack, salmon may have been unable to ascend the falls at all.

It is also possible that the falls may not have been passable to salmon during the early-mid Holocene because of lower sea levels. During the past 12,000 years, sea level rose nearly 110 m (Peterson and Phipps 1992, USGS 2008). Sea level began stabilizing at around 3000 years BP, rising less than 5 m from this time to the present (Peterson and Phipps 1992). Additionally, early rapid accumulation of sediment in the Columbia Basin, prompted by abruptly rising sea levels (Peterson and Phipps 1992) further increased river elevation over time. Therefore, a passable falls may have been a consequence of sediment in-filling associated with glacial melt and rising sea levels during the early Holocene. Therefore, fish passage above Willamette Falls may only have been possible within the last 3000 years, around the time when sea levels stabilized.

In addition to temporal constraints on fish passage and distribution provided by Willamette Falls, the origin of the tributaries of the Willamette River above Willamette Falls affects salmon spatial distribution. Galbreath (1965) notes that "the spring Chinook salmon ran only in the larger tributaries heading in[to] the Cascades…" which includes the North and South Santiam, McKenzie, and Middle Fork tributaries. In addition, Galbreath's (1965) analysis of the timing of fish runs in the lower Columbia River region notes small salmon runs in the Molalla, Pudding, and Calapooya Rivers of the Coast Range, but no runs in the Tualatin, Yamhill, Luckiamute, Marys, and Long Tom Rivers. Zenk (1976:73-74) speculates that the distribution of fish runs observed by Galbreath (1965) and Fulton (1968, 1970) reflect that the most favorable conditions for salmon spawning occur in relatively large streams with high altitude headwaters, which tend to occur in the Cascade Range mountain on the valley's east side.

Ethnohistoric Record of Subsistence in The Willamette Valley

The archaeological interpretation of the subsistence practices and culture of Willamette Valley Native people is heavily informed by historical accounts and ethnographic records from the region. In the early 19th Century when Euro-Americans were beginning to enter the valley, the Willamette Valley was occupied by approximately 13 “tribes” of people, collectively known as Kalapuyans, for their shared linguistic and cultural traits (Zenk 1990). In 1814, Alexander Henry (Coues 1897:814) reported that plant resources, and specifically roots constituted the bulk of the Kalapuyan diet. This account, combined with reports that salmon simply could not travel above Willamette Falls (Ross 1859, Coues 1897), supports the view that salmon were not a part of indigenous subsistence strategies.

However, other ethnohistoric accounts dating thirty years later suggest that salmon were not only able to ascend the falls, but that Native groups were actively harvesting these fish (Wilkes 1845:344-345). Wilkes (1845:344) writes that:

> The salmon leap the falls; and it would be inconceivable, if not actually witnessed, how they can force themselves up and after a leap of from ten to twelve feet retain enough strength to stem the force of the water above.

Additionally, the Hudson's Bay Company set up a trading area at the falls, purchasing 800 barrels of salmon in 1841 from Native groups in the area (Craig and Hacker 1940).

The contrasting perspectives regarding both 19th century observations of regional subsistence practices, as well as whether salmon could ascend Willamette Falls highlights the importance of understanding context from which the ethnohistoric record was drawn. There are few early ethnohistoric accounts from the Willamette Valley (Zenk 2008). The scarcity of ethnohistoric records documenting the use of salmon above Willamette Falls may simply be due to the limited writings from the region overall, or a lack of writings at the appropriate time, or whether the observations were in the appropriate location to observe salmon exploitation. Adding to this complexity, large-scale epidemics in 1782-1783 and 1830-1833 (McKinney 1984:31, Zenk 1990:551) caused massive decline in the Native American population in the Willamette Valley from nearly 32,000 people prior to 1830 to just over 2,100 people after the mid 1830s, resulting in the total abandonment of many villages (Boyd 1975: 135-136). This event was followed closely by the removal of the Kalapuyan people from the Willamette Valley at the end of the 1850s (Spores 1993:171). The catastrophic population decline and dispersal of the Kalapuyan people almost certainly resulted in the loss of cultural practices. Spores (1993:172) notes that:

> Even before the arrival of the Lewis and Clark expedition in 1803[1], trade goods and diseases brought by white men had begun to alter Native Life in the Willamette Valley. Although whites were trickling into the valley during the 1830s, it was not until the 1840s that farmers, traders and missionaries settled the area in appreciable numbers, and by this time the Native population had already been drastically reduced.

The opportunity for Euro-Americans to observe Indian fishing practices was further diminished by the timing and location of early Euro-American settlements. Bunting (1995:418) notes that fewer than a dozen farms had been established in the Willamette Valley prior to 1850, with just a few more attempted by the 1880s. Additionally, Euro-Americans that immigrated to the region tended to avoid floodplains, and instead chose to inhabit upland, grassland, and near-timberline areas. Around 90 % of the farms established in the Willamette Valley were located in these areas in the 1850s (Bunting 1995: 417).

Scholarly ethnographic research in the region began with A.S. Gatschet's 1877 interviews with the Chinook and Kalapuya people of the Willamette Valley (Zenk 2008:9). Further early ethnographic research in the Willamette Valley included recording languages and place names. However, Zenk (2008:8) notes that:

> A handful of Native elders born into the era of Euro-American frontier expansion, which saw the virtual obsolescence of all Northwest Oregon indigenous languages and lifeways, are responsible for most of what we know about these languages.

[1] Note: Lewis and Clark arrived in the Lower Columbia River area in the fall of 1805.

From these records, anthropologists have tended to present Willamette Valley native peoples as an exception to the rule that the Native people of the Pacific Northwest relied on salmon. It is on this basis that the Northwest Power Planning Council concluded that the ethnographic literature from the Willamette region is not likely to add much to our understanding of the past distribution and abundance of salmon populations (1986:36).

Interestingly, a single scholarly ethnographic researcher, working in the late 1920's and early 1930's, discussed salmon exploitation above Willamette Falls. From oral traditions of elders, Jacobs (1945) noted that the Kalapuya of the Santiam River fished for salmon, steelhead, trout, and eels (local common name for lamprey *Lampetra* spp.). Trout were caught using line and lures, while salmon and steelhead were captured using spears.

Criticisms of the Direct Historical Approach

The common view that indigenous peoples of the Willamette region did not consume salmon is likely derived from two assumptions: (1) The ethnohistorical record yields a mostly unmodified view of the behavior of prehistoric people, and (2) The regional archaeological record is a representative sample of subsistence behavior. The first point will be explored in the following discussion, while the second will be explored later in this thesis.

Much of what we know about the subsistence practices of the prehistoric Kalapuyan people comes from application of the direct historical approach. This approach uses historical or ethnographic information about existing cultures to interpret archaeological data from an earlier time period (Stewart 1942, Trigger 1996: 510). It is generally applied in order to identify ethnographic affiliation, construct chronologies, and to gain insight into the human behavior that may have produced the archaeological record (Lyman and O'Brien 2001:310). Based on the above mentioned ethnographic sources suggesting local reliance on plant food, application of the direct historical approach would lead one to conclude salmon were not utilized in this area. This conclusion is questionable, however. While the direct historical approach can yield important connections between past and present behavior, it has limitations.

The divide between ethnographically recorded culture systems and the pre-contact past potentially limits interpretation of what was and was not done in the past. Dunnell (1989) argues that the catastrophic decline of North American Native American populations affected cultural continuity between ethnographically recorded cultures and pre-contact cultures. For example, Dunnell (1989:565) points to "the [Euro-American] notion that since Indians were not known to build mounds historically they did not do so in the past." Catastrophic population decline represents a reduction in the total range of variability, known as the Founder Effect (Dunnell 1989:570). In the context of

North American native populations, post-depopulation cultural systems represent a fraction of the total range of cultural behaviors exhibited during pre-contact times. This effect is further exacerbated by the demographic shift associated with epidemic diseases, where the very young and old are disproportionately killed (Trigger 1966:439-440). Furthermore, Schalk (1986) notes that not only had Native cultures been significantly affected by disease prior to Euro-American contact, but also by the introduction of the horse, which increased the mobility and range of many Native groups.

In addition, methods used by early ethnographers probably contributed to the loss of knowledge about the 19th century. For example, early ethnographers aggregated culture groups into "tribes" by linguistic criteria rather than by individual bands or groups that either lived or subsisted together. Schalk (1986:4) suggests that this is an issue because "the patterns of food resource use from one band to the next… were often highly variable." Schalk (1986:4) notes too, that "…most ethnographic studies tend to focus on typical patterns of behavior rather than the range of variation."

Finally, there are complications regarding the temporal and spatial resolution of data collected from informants. Wobst (1978:305) notes that informants observe behavior closest to their location. When distance from that location increases, the informants detailed knowledge of cultural behavior decreases. This relationship is also an issue when considering time depth. Lyman and O'Brien (2001: 317) note that ethnographic analogy, key to the direct historical approach, “works progressively less well as the subject archaeological manifestation increases in age.”

In sum, there are a series of issues to consider when using ethnographic data to inform interpretations of behavior in the archaeological record. For example, one must consider whether there is potential for discontinuity affecting the variety of behaviors expressed, either through epidemic disease or migration prior to the collection of ethnographic data, as well as when this discontinuity took place. Additionally, one must consider the observer and/or informant’s relationship, both spatially and temporally, with either the behavior or event that is being researched. Finally, one must consider how the ethnographer groups cultures, and the types of generalizations drawn from this aggregation.

It is unclear how much rapid population decline and displacement affected representation of the range of Native cultural behaviors in the region. Nor is it likely, based on their settlement patterns, that Euro-Americans in the Willamette Valley were present at the right location, or at the right time to observe Native subsistence practices that would have included salmon exploitation. Furthermore, most traits characteristic of cultural practices for the entire Willamette Valley were drawn from knowledge of only two groups who lived in the northern end of the valley, with streams of limited salmon runs during historic times. It is unlikely that the same pattern of subsistence was ubiquitous throughout the valley, especially considering that neither the

Yamhill nor the Tualatin drainage is known to have large salmon runs relative to other sub-drainages south of Willamette Falls (Zenk 1976). Since the Willamette Valley ethnographic record is particularly fragmented and incomplete, one cannot reasonably argue that it represents (1) unmodified cultural practices or (2) the full range of cultural behaviors of the 19th century, much less centuries before. Therefore, it is best suited for describing behaviors that were observed rather than ruling out expected behaviors that were not. Only through analysis of the archaeological record can these expected behaviors, such as salmon exploitation, be tested.

Overview of Willamette Valley Archaeology

In the Pacific Northwest and the Plateau, salmon and steelhead were considered favored foods by indigenous peoples (Schalk 1986, Ames 1994, Matson and Coupland 1995, Ames and Maschner 1999). The exploitation of salmon as a food source has a long history in the Pacific Northwest dating back as far as 9000-10,000 years before present (Cressman et al. 1960, Butler and O'Connor 2004), and the exploitation and storage of salmon is considered to be one of the primary factors in the development of semi-sedentary hunter-gatherer society in the Pacific Northwest (Schalk 1981, Matson 1992, Ames 1994:211). However, there is debate as to whether increased use of salmon led to the emergence of complex societies (Butler and Campbell 2004:389), with the rationale that if salmon were important to the development of sedentism, then use of this resource would intensify as this practice developed. Nevertheless, salmon represent a ubiquitous and consistently utilized resource in the Pacific Northwest.

Willamette Valley archaeological overviews have highlighted finds that support the view that camas (*Camassia quamash*), as well as other plant resources, were exploited. For example, bank erosion at the Havannan Creek Site exposed multiple hearth/roasting pit features, as well as nearly 350 charred camas bulbs, which were radiocarbon dated to between 7750 and 6830 BP (Aikens 1993), suggesting that the practice of camas exploitation has a long history. The Perkins Park, Upper Long Tom River, Kirk Park, Flanagan, Benjamin, Hurd, Hagar's Cove, and Fuller and Fanning Mound sites all have roasting features and charred bulbs, as well as other macrobotanical remains (Aikens 1993:193-212).

Previous general syntheses of Willamette Valley Archaeology suggest that faunal remains are relatively scarce. Highly fragmented mammal and bird bones were found at the Perkins Park Site; faunal remains were present at the Kirk Park, Cascadia Cave, and Rigdon's Horse Pasture Cave site, with deer representing the predominant taxa (AIkens 1993). Salmon remains were not mentioned in Aikens' (1993) Willamette Valley archaeological synthesis. Interestingly, of the five sites. AIkens mentions with any faunal remains, two are located in caves, which tend to have favorable preservation conditions. These observations are echoed by Lyman (1987: D.1), who notes that very few sites from areas south and west of the Willamette Valley contain zooarchaeological remains. Lyman further suggests that the high soil acidity in the Willamette Valley may explain the relative absence of faunal remains. Additionally, Thoms (1989:307) notes that fine screening and flotation were not used before the 1980s, thus sampling technique cannot be ruled out as a factor in faunal representation in the Willamette Valley. In summation, it is probable that factors such as preservation conditions and data collection methods are affecting the discovery of faunal remains in the Willamette Valley.

McKinney (1984: 28), in her review of Kalapuyan subsistence, notes that gear (eg. net weights, clubs) associated with fishing has been found above Willamette Falls on the Yamhill River. This suggests, at the very least, that some kind of fishing activity occurred above the falls; whether this gear was used to catch salmon or other fish is unknown. Additionally, Laughlin (1943) notes that fish vertebrae are present at the Fuller and Fanning mounds near the Yamhill River. These remains were not identified beyond “fish vertebrae.” This evidence further bolsters the claim that some kind of fishing took place above Willamette Falls.

The prevalence of camas ovens above Willamette Falls, and the lack of discussion of salmon remains in regional archaeological overviews (White 1979:567, Pettigrew 1990) supports the view that plants were intensively used in the region, while salmon were not. However, it is unclear, in regional site overviews, if absence of faunal remains from the record is due to their true absence, archaeological recovery methods, omission of faunal data from site reports, or context of archaeological sampling (e.g. have sites been sampled adjacent to rivers where remains of fishing activities are most likely to be found?). Furthermore, heavy reliance on the direct historical approach by archaeologists has re-enforced the view that Native peoples were mainly plant eaters in the ancient past.

Factors that Affect Faunal Representation in the Archaeological Record

The study of zooarchaeological remains can provide a record of human-animal relationships over time and space, which can then be used to create a record of specific animal distributions over varying temporal and spatial scales. However, this view must be qualified by an understanding of what presence, and more importantly, absence of animal classes in the zooarchaeological record means. Without this context, it is likely that patterns in faunal representation in the archaeological record may be a function of sample design or other factors, rather than the actual relationship between humans and animals.

When an expected artifact class is present, the implications are clear, the artifact in question was used, deposited, and preserved. Absence, however, is a complicated state that involves multiple possibilities, stemming from the human behavior that created cultural materials and in sampling design, which makes analysis difficult (e.g. Was the resource or artifact not used? Did it not preserve? Has there been enough archaeological research to know?). The ambiguity regarding whether Native people of the Willamette

Valley exploited salmon provides a perfect opportunity to explore the importance of zooarchaeological analysis, as well as the complexities associated with the interpretation of presence and absence in the archaeological record.

The archaeological record is a product of human behavior, reflected in both the initial deposition and subsequent collection of cultural materials. Schiffer (1983, 1996) differentiates between cultural processes, those directly linked to the behavior that led to initial deposition, and environmental processes, which act on material culture after deposition. Initial human behavior (cultural processes) dictates the variety and distribution of cultural materials on the landscape (e.g. Binford 1980), while environmental processes may modify the pattern of these materials by selectively preserving specific classes of cultural materials (e.g. Stein 1992). Finally, archaeological sampling, including site excavation design, volume excavated, and mesh size (Schiffer 1996), further affects the variety and distribution of materials that are collected. In sum, we need to consider and evaluate the role of natural processes and sample design given the amount of research that highlights their effects on interpretations of original human behavior.

Artifact preservation, a natural process, is a factor that one must consider when trying to interpret patterning in archaeo-faunal distributions. Importantly, one cannot modify their research design to mitigate the effects of preservation conditions. Instead, *post hoc* knowledge of preservation conditions from a given region helps a researcher determine whether or not absence is a function of preservation.

It is important to recognize how research design characteristics allow for the detection of salmon elements. More generally, in order to determine whether the archaeological sample from a given region is adequate to assess archaeological questions that are quantitative in nature, or to discern cultural materials with specific constraints that affect visibility, one must identify which factors affect the abundance and distribution of the targeted class of items on the landscape. These factors include excavation methods, location of excavation, and volume excavated at sites (Schiffer 1996). Additionally, one must attempt to determine if methods, including sample location on the landscape, and volume excavated (Wolff 1974) allow for the discovery of items that are potentially rare. In order to do this, one must assess whether the item one is trying to perceive is simply rare, or rare and also found in selected places, or rare, found in selected places, and difficult to see (Lyman 1995: 371). Once the nature of the desired data is understood, one can modify their sample design to detect the class of item by increasing sample size, decreasing mesh size, and/or increasing the resolution with which one can predict the location of a given resource. Placing this discussion in the context of zooarchaeology, sample design modification should vary by size of taxa, intensity of exploitation, and location of exploitation.

Here, I discuss the main attributes of sampling design that affect whether the archaeological record includes fish bones. Since I will be compiling and analyzing zooarchaeological records from the Willamette Valley, I will need to address how methodological factors affect salmon bone representation in the archaeological record, since these are the easiest to control for.

Excavated Volume

As the excavated volume increases, assemblages tend to increase in size and variety (Lyman 1995, Thomas 1989). As a result, with a relatively small sample size, a limited variety of activities will be represented, and the probability of finding rare items decreases. Unfortunately, there is no metric with which to assess whether the amount of material excavated in the region is adequate to register rare items, or specific taxa. However, there are multiple methods (species-area curve, bootstrapping, rarefaction) to determine whether the richness of any given artifact assemblage adequately reflects the richness of the underlying population (Cochrane 2003, Lyman and Ames 2007).

Mesh Size

The effect of mesh size on faunal representation is well-studied (Thomas 1969, Grayson 1984, Cannon 1999), as is the research regarding the effect of mesh size on fish faunal representation (Casteel 1972, Nagaoka 2005, Zohar and Belmaker 2005). Research by Butler (1993) even explores the effect of mesh size on differential recovery of salmonid elements.

However, it is difficult to list a specific mesh size that is the point at which one starts recovering salmon remains. This is partially because of the variability in salmon body size among species and extent of fragmentation. The species that migrate through to the Willamette River system are relatively large bodied. Adult steelhead are between 5 and 10 pounds (2.5 to 4.5 kg, Wydoski and Whtney 2003: 73-84). Adult coho salmon are similar in size, most weighing between 8 and 12 pounds (3.6 to 5.4 kg, Wydoski and Whtney 2003: 73-84). Adult chinook salmon are larger than coho salmon and steelhead, at around 22 pounds (10 kg, Wydoski and Whtney 2003: 73-84). Since most of the cranial and pectoral elements, as well as relatively complete vertebrae of adult salmon are recoverable in ¼" mesh (Casteel 1972, Butler 1993), research designs that have the potential to recover salmon remains should minimally screen soil through ¼" mesh. On the other hand, if remains are extremely fragmentary, smaller mesh sizes (1/8", 1/16") would be needed.

Location and Site Distributions

Known site distributions represent a combination of original settlement patterns and land use activities and contemporary archaeological field practices. The original human behavior underlying land use affects both site distribution and the content of sites, and is independent of research design. Comparatively, a researcher's sampling design can greatly affect the probability of discovering sites linked with particular activities, such as fishing or long term use.

Optimal foraging theory can be used to develop expectations, likelihoods, and obtain rationale for locations on the landscape that should be linked to fishing activities. Jones and Madsen (1989) suggest that for a given resource, there is a distance at which the caloric cost of transportation exceeds the caloric gain provided by the exploited resource. Transportation costs, which include resource weight, and distance between catch locations and central base, are logistical considerations when exploiting resources (Metcalfe and Barlow 1992). Therefore, the presence and abundance of salmon remains in archaeological sites should be inversely related to distance from the location where salmon would be collected. In other words, sites that yield salmon remains should be close to a water source where salmon are present. However, the issue of “how close” is not well studied. For this project, sites will be included if they fall within the Willamette drainage, as delineated by drainage polygons downloaded from the USGS National Hydrograpic Dataset website (http://nhd.usgs.gov/data.html).

The known distribution of sites may be representative of the population of archaeological sites in the region or it may only represent a limited variety of sites, as a function of the sample design used. Most of the known sites in the Willamette Valley were found in the course of Cultural Resource Management projects (CRM). While this is no different than most parts of the United States, it is important to recognize that site distributions are a product of both ancient human behavior but also sampling that was primarily driven by 20th century development.

Preservation

A confounding factor that supercedes the consideration of mesh size, excavation location, and volume excavated is whether the object one is looking for preserves in the archaeological record. Some objects, such as stone tools, tend to preserve well, while preservation of faunal material, wood, and plant fiber varies depending on a range of factors, including condition of deposition, speed of burial, and depositional environment (e.g. soil P.H., sediment grain size). Faunal material, in particular, can be sensitive to the surrounding environment. Processing and digestion (Lubinski 1996: 175), faunal attributes such as bone density, size, shape (Butler and Chatter 1994), and porosity (Lubinski 1996: 175) all affect preservation of faunal materials. Additionally, different elements preserve differentially in archaeological sites. Flat, thin bones, such as cranial and fin elements, are usually the first to degrade over time, while denser bones, such as vertebrae, tend to degrade at a slower rate (Lubinski 1996: 179-180). Within the Willamette Valley, Lyman (1987: D.1) notes that very few sites from the southern portion of the valley contain zooarchaeological remains, and further suggests that the high soil acidity in the region may explain the relative absence of faunal remains. If true, then we would expect scarcity of faunal remains from all vertebrate classes across the region. On the other hand, if all vertebrate classes but salmon are represented in archaeological sites, then poor preservation could not be cited to account for the scarcity of salmon remains.

Summary

In the Pacific Northwest, salmon are viewed as central to the Native American diet, when available. Environmental and ethnohistorical evidence indicate that salmon were able to ascend Willamette Falls and were in the middle and upper reaches of the Willamette River. However, previous archaeological and ethnographic overviews of the region indicate that salmon were not used. Analysis of the composition of the ethnographic record, and the direct historical approach, reveals that there are limitations to using ethnographic information to rule out expected cultural behaviors. Finally, since the archaeological record represents a sample of human behavior filtered by post-depositional and methodological factors, it is necessary to determine whether patterns in the archaeological record represent original human behavior or differential recovery of artifacts.

Chapter 3: Compilation and Synthesis of Archaeological Records above Willamette Falls

Report Collection Methods

To create the most comprehensive zooarchaeological record for the Willamette Valley possible, I used a variety of database searches at the Oregon State Historic Preservation Office (SHPO) in Salem, Oregon, including those encapsulated in ArcGIS, the SHPO's Geographic Information System. First, I generated a list of known sites located in the Willamette Valley, and it's tributary basins. To do this, I uploaded two-dimensional polygons into the SHPO GIS system, which represent the shape and location of the Willamette Valley and its tributary basins, including the Tualatin, Mollala-Pudding, Yamhill, North Santiam, South Santiam, McKinney, Mid-Fork Willamette, Coast Fork Willamette, Upper Willamette, and the Mid-Willamette (Figure 2). I excluded two sub-basins, which are downstream of Willamette Falls, since the main debate concerns salmon use upriver of the falls. The remaining ten sub-basins became the organizing unit for my study, with all site records being compiled within each.

I made every effort to include all site excavation reports within the Willamette Valley as of June 2009. However, some reports may have been left out of analysis, due to factors such as site point location errors on the GIS database, report omissions from the library database, and human error. I learned in January 2010 about one site report that was not included (Fagan et al 1994). While there may be a few records missing from my study, I do not think such omissions have materially affected the results of my study, given the comprehensiveness of my review.

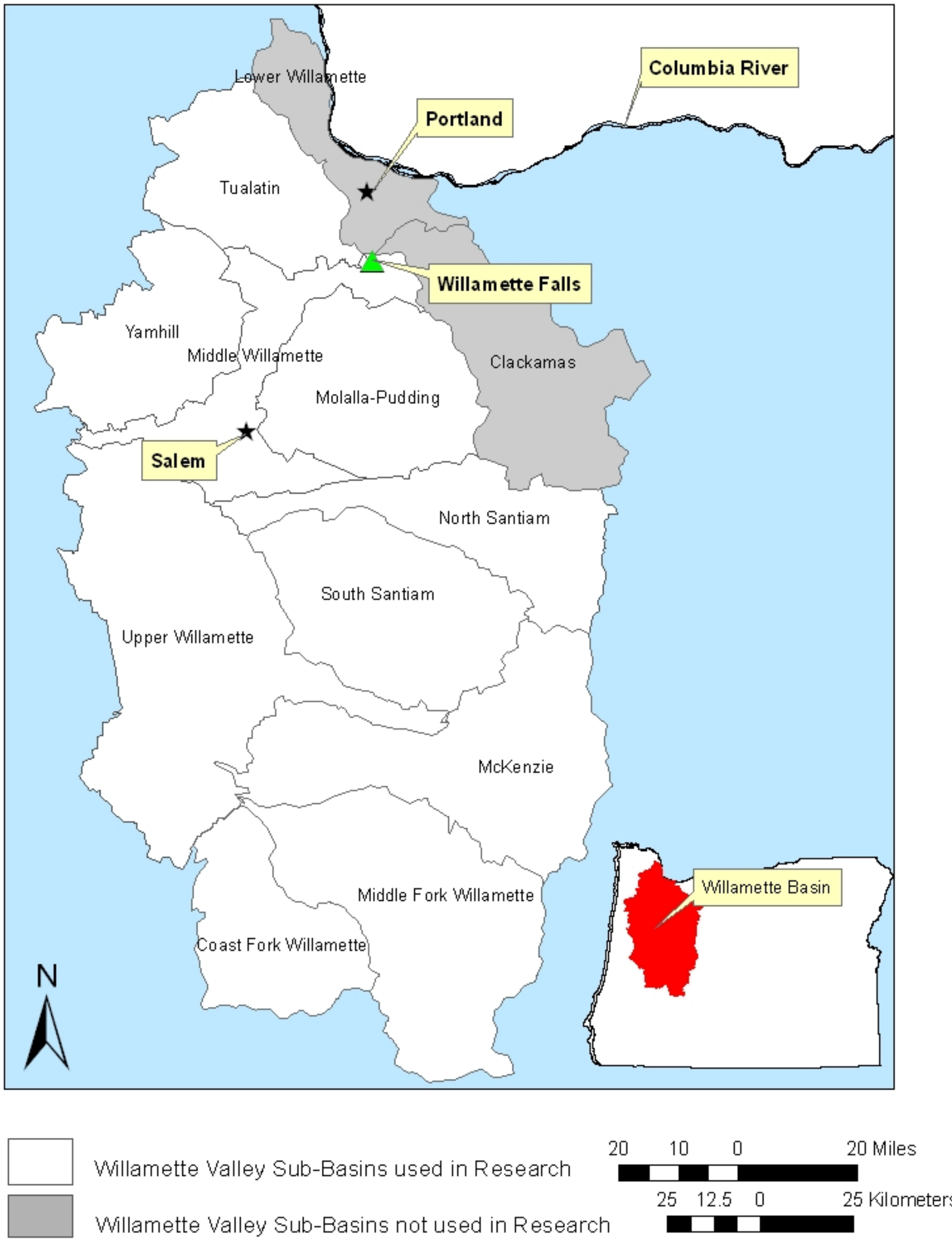

Figure 2. Location of Willamette Valley Sub-Basins

I then queried site numbers that fell within these polygons. Basin polygons were collected from the USGS National Hydrograpic Dataset (http://nhd.usgs.gov/data.html). The site lists generated were then cross-checked using the SHPO's bibliographic software to locate associated archaeological investigation reports.

From this list, I closely examined all reports with excavated site contents, including shovel test pits and shovel test units, unless they were reporting on Euro-American historical sites, which would not yield Native subsistence data. Historical site reports were omitted from further analysis.

From each site report, I obtained information on the following attributes: collection method, mesh size, area and volume sampled. I also recorded information on site chronology, plant remains, and fish-related artifacts if present. Site chronology is needed to establish the timing of subsistence changes, especially the possibility that salmon passage was affected by sea level change. Recording plant tissue information provides knowledge on the extent of non-animal food consumption. Finally, several reports included information on animal protein residue. This information was recorded as well, since this information could also help address whether the native peoples of the Willamette Valley used salmon.

Once reports were collected from the Oregon SHPO and recorded, I noted the number of reports that listed the mesh size used in the excavation as less than or equal to ¼”, as well as listed the volume of soil excavated. A maximum threshold for mesh size of ¼” was selected because use of larger mesh or no screening at all limits one’s ability to recover salmon remains, therefore making it impossible to determine whether absence of salmon in the archaeological record is a function of cultural processes, post depositional processes, or archaeological sampling methods. Site reports that omitted information on excavated volume, screen mesh size, or did not collect faunal remains were noted, but would not have been used to assess the size of the faunal sample had there been more faunal data in the Willamette Valley, unless salmon remains were recovered during excavation. The reasoning behind including site records with salmon remains that lack sample design information is that sample size assessment becomes unnecessary if salmon remains are present, given that the overall goal is to determine whether salmon were used prehistorically. Once I located and tallied all sites that had faunal remains from excavation reports, I listed the contents of sites that had faunal remains that were identified to a taxonomic group (Table 2). Sites with faunal remains that were not identified to a taxonomic level, remains that were identified but not counted, or remains that were clearly associated with historic occupations in multi-component sites were included in the tally for the total number of sites with faunal remains, and were used to explore faunal preservation in the Willamette Valley.

After compiling the site report information, I used ArcMap to determine the distribution of sites with faunal remains on the landscape relative to the Willamette River and its tributaries (the source of salmon) to better assess whether sites are in appropriate locations for the detection of salmon remains. Using the distance measuring function on ArcMap, I recorded the distance between sites and the nearest salmon source. If multiple sites with faunal remains were located near a salmon source, this would support the case that archaeological locations and preservation were not responsible for scarce or absent salmon remains.

After analyzing the site records of the Willamette Valley, I determined which factors (number of sites, mean volume excavated, mesh size), which I could control for, had the strongest effect on faunal representation. To do this, I cross-compared the number of sites with faunal remains in each sub-basin with the number of sites, mean volume excavated, and mesh size using a scatter-plot diagram. I used the linear regression analysis tool in Microsoft Excel to determine the slope of the line formed by the sequential alignment of the independent numerical variable, in ascending order, of the nine sub-basins to determine the correlation coefficient (R^2) for each value paired with number of sites with faunal remains.

To estimate the amount of error in my data collection I re-analyzed a ten percent sample of reports, selected using a random number generator provided by Random.org. I recorded 18 out of 19 attribute categories for each site. This sample size was selected out of convenience, but it represents a 20% margin of error using a 95% confidence interval (http://www.raosoft.com/samplesize.html). Of the sites selected, a single error was found relating to reported mesh size at 35-LA-71, representing a recording error of 1/5th of one percent (or 1/504).

Results

Records Compilation

A total of 286 sites in the Willamette Valley have received some sub-surface testing (e.g., shovel test pits, shovel test units) (Table 1). The following highlights specific results by sub-basin.

Table 1. Willamette Valley Archaeological Sites Summary Table

Sub-Drainage	# excavated sites	# sites, mesh size ≤ 1/4”	# sites with volume information	Total Volume (mean) m^3	# sites that list volume and mesh size	# sites with faunal remains	# sites with plant remains	# sites with fishing gear	# sites, lithics – fish residue
Mid Willamette	68	50	39	108.2 (2.8)	29	13	7	0	2
North Santiam	24	20	16	40.5 (2.5)	16	3	4	0	3
South Santiam	37	34	22	43.9 (2)	20	3	0	0	0
McKenzie	33	31	27	66 (2.4)	22	2	0	0	0
Coast Fork	14	13	11	25.8 (2.3)	11	1	0	0	0
Middle Fork	39	30	14	31.7 (2.3)	14	7	6	1	0
Molalla	3	3	0	N/A	0	1	0	0	0
Tualatin	6	5	4	13.8 (3.5)	4	2	1	0	0
Yamhill	14	9	2	3.2 (1.7)	2	0	0	1	0
Upper Willamette	48	46	30	164.4 (5.5)	28	7	5	0	0
Total	286	241	165	497.5 (3)	146	39	23	2	5

Mid-Willamette Valley

Faunal materials were identified in 13 sites. However, with the exception of two sites, materials were not identified to a taxonomic group beyond “”small”, “medium” or “large” mammal. In addition, explicit discussion of faunal analysis methods was rare. A single “pig” tooth was identified at 35-PO-83 (McCormick and Roulette 2008), which was attributed to a historic occupation. A canine (taxon unspecified) tooth was identified at 35-PO-3 (Thoms and Carlevato 1981). Multiple faunal remains were identified to the genus taxonomic level at 35-LIN-468 (Fagan et al. 1992).

Botanical remains were identified at seven sites. Camas (*Camassia quamash)* was the most commonly reported plant, followed by hazelnut (*Corylus cornuta)*. Three net weights were recovered from 35-MA-57 (Bell, No Date). Tools analyzed for blood residue tested positive for “trout” at sites 35-LIN-451 and 470 (Fagan et al. 1992).

The Mid-Willamette region had the largest number of sites, as well as sites with faunal remains and plant remains, relative to the other Willamette sub-drainage regions.

North Santiam

Faunal materials were identified in three sites. The majority of the bone was identified as “”small”, “medium” or “large” mammal. Bovine bone was identified at 35-MA-107 and 35-MA-114 (Fagan et al. 1992). One site (35-MA-

92) had faunal materials, however no fauna were identified at a level finer than vertebrate class (Silvermoon 1990).

Botanical remains were identified at four sites, including camas, hazelnut, chokecherry (*Prunus virginiana)*, English walnut (*Juglans regia)*, salmonberry (*Rubus spectabilis)*, red cedar (*Thuja plicata*) and Douglas fir (*Pseudotsuga menziesii*). Tools analyzed for blood residue tested positive for “Trout” at sites 35-MA-105, 107, and 114 (Fagan et al. 1992).

One site (35-MA-107), located in the North Santiam sub-drainage, was also listed in the Mid-Willamette dataset. Information about this site is provided in two reports I included site records in the North Santiam dataset.

South Santiam

Three sites, 35-LIN-363 (Winthrop and Gray 1988), 391 (Flenniken et al. 1990), and 660 (O'Neill and Jenkins 2001), had faunal remains, the majority of which were identified as “medium mammal bone.” A single squirrel (Sciuridae) incisor was found at 35-LIN-660.

McKenzie

Two sites (35-LA-390, 951) had faunal remains. Three faunal specimens identified to the group taxon Catostomidae/Cyprinidae were found at 35-LA-951 (Toepel and Bland 1991). Site 35-LA-390 had a single faunal fragment not identified to taxon or element (Jenkins 1986).

Coast Fork

A single site (35-LA-1228) had a single faunal fragment that could not be identified to taxon or element (Tasa and Connolly 2000).

Middle Fork

Seven sites had faunal remains (35-LA-39, 190, 191, 656, 801, 802, and 1026), and two (35-LA-801 and 802) had associated faunal tables with fragments that were identified to species (Churchill and Jenkins 1989).

Six sites had floral remains, but only one site (35-LA-802) listed the results of floral analysis in the report. Hazelnut and Douglas fir were found at this site. A single net-sinker was found at 35-LA-285 (Winkler 2005).

Molalla

A single site (35-CL-122) yielded faunal remains that were not identified to taxon or element (Fagan et al. 1992).

Site 35-MA-94 was also listed for the Mid-Willamette drainage, and the site was documented in two reports. I placed both site records in the Molalla drainage dataset.

No soil volume was recorded from reports in this sub-basin.

Tualatin

Two sites (35-WN-4, 45) had bone fragments that were not identified to taxon or element.

Floral remains (acorn shells) were recovered from one site, 35-WN-45 (Ellis and Forgeng 1998). A single “ball”, referred to as a net-weight, was located at 35-WN-4 (Davis 1970).

Blood residue analysis was carried out on lithics at 35-WN-45, which tested positive for duck (Family Anatidae) or pigeon (Family Columbidae) residue.

Yamhill

Faunal remains were not found at any site in the Yamhill sub-basin.

Upper Willamette

Seven sites (35-BE-10, 37, 39, 35-LA-218,1283, 35-LIN-659, 683) had faunal remains. Of these, five sites (35-BE-10, 37, 39, 35-LA- 218, 1283) had faunal remains that were identified to the genus or species level.

Floral remains were found in five sites (35-LA-42, 626, 628, 683, and 1283). Camas was the most commonly identified plant.

The Upper Willamette sub-basin had the second highest number of sites when compared to other sub-basins. In addition, the Upper Willamette sub-basin had, by far, the highest mean soil volume excavated per site when compared to the other sub-basins, an attribute that may help to explain why it also had the most sites with faunal remains that could be identified to a genus or species level.

Summary of Willamette Valley Faunal Assemblages

Thirty-nine out 286 sites (or around 15%) that have received some sub-surface testing have faunal remains (Table 1). Mesh size and volume excavated were listed for 28 of these. Of the 39 sites with faunal remains, 26 either had a faunal assemblage that was too fragmentary to identify to any taxonomic level, remains that were identified as present but not quantified, or remains that were clearly associated with historic occupations. The remaining thirteen sites provided very few identified faunal remains (n=373) and no salmon remains (Table 2).

Table 2. Summary of Identified Faunal Remains in Willamette Valley Archaeological Sites

Sub-Drainage	Mid-Willamette	Upper Willamette	Middle Fork	Middle Fork	Middle Fork	Middle Fork	Middle Fork	S. Santiam	Upper Willamette	Upper Willamette	Upper Willamette	Upper Willamette	McKenzie	
Site	35-LIN-468	35-LA-218	35-LA-801	35-LA-802	35-LA-190	35-LA-191	35-LA-656	35-LIN-660	35-LA-1283	35-BE-10	35-BE-37	35-BE-39	35-LA-951	
Citation Page No.	Fagan et al 1996 Appendix	Toepel & Minor 1980 196-201	Churchill & Jenkins 1989 p. 101-110	Churchill & Jenkins 1989 p. 101-110	Churchill 1989 p. 36-37	Churchill 1989 p. 47-48	Churchill 1989 p.63-64	O'Neill & Jenkins 2001	Oetting 2005a	Havercroft 1985	Havercroft 1985	Havercroft 1985	Toepel & Bland	Total
Mesh Size	Unlisted	1/4"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"	1/4"	1/4"	Unlisted	
Mammalia														
Equus ferus caballus		2										2		
Bison bison		3										1		
Bos taurus	2	1												
Ursidae	1													
Ursus horribilis	3		1											
Ursus americanus	1													
Artiodactyla		1												
Cervidae	3													
Urocyon cineroargentus							1							
Cervus canadensis	3													
Odocoileus spp	9	12	17	3		2			1			21		
Odocoileus hemionus							25							
Canis sp.	5	13												
Lynx rufus	5						1							
Lynx candensis candensis			2											
Mustelidae	1													
Lutra canadensis	1													
Castor canadensis	3	1												

Sub-Drainage	Mid-Willamette	Upper Willamette	Middle Fork	Middle Fork	Middle Fork	Middle Fork	Middle Fork	S. Santiam	Upper Willamette	Upper Willamette	Upper Willamette	Upper Willamette	McKenzie	
Site	35-LIN-468	35-LA-218	35-LA-801	35-LA-802	35-LA-190	35-LA-191	35-LA-656	35-LIN-660	35-LA-1283	35-BE-10	35-BE-37	35-BE-39	35-LA-951	
Citation Page No.	Fagan et al 1996 Appendix	Toepel & Minor 1980 196-201	Churchill & Jenkins 1989 p. 101-110	Churchill & Jenkins 1989 p. 101-110	Churchill 1989 p. 36-37	Churchill 1989 p. 47-48	Churchill 1989 p.63-64	O'Neill & Jenkins 2001	Oetting 2005a	Havercroft 1985	Havercroft 1985	Havercroft 1985	Toepel & Bland	Total
Mesh Size	Unlisted	1/4"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"	1/4"	1/4"	Unlisted	
Procyon lotor	3										7			
Spilogale putorius	1													
Lepus spp.	1													
Lepus americanus washingtonii			2											
Sylvilagus spp.					1		5							
Sylvilagus bachmani	4													
Sciuridae	1							1						
Tamiasciurus spp.							1							
Otospermophilys beecheyi	1													
Eutamias spp.	-						1							
Eutamias townsendii			2											
Eutamias sabrirus			1											
Thomomys spp.	20						3							
Microtus spp.	2		1							1				
Microtus montanus			1											
Rodentia	5													
Neotoma spp.												1		
Neotoma cinerea fusca			3				1							
Muroidea		5												

Sub-Drainage	Mid-Willamette	Upper Willamette	Middle Fork	Middle Fork	Middle Fork	Middle Fork	Middle Fork	S. Santiam	Upper Willamette	Upper Willamette	Upper Willamette	Upper Willamette	McKenzie	
Site	35-LIN-468	35-LA-218	35-LA-801	35-LA-802	35-LA-190	35-LA-191	35-LA-656	35-LIN-660	35-LA-1283	35-BE-10	35-BE-37	35-BE-39	35-LA-951	
Citation Page No.	Fagan et al 1996 Appendix	Toepel & Minor 1980 196-201	Churchill & Jenkins 1989 p. 101-110	Churchill & Jenkins 1989 p. 101-110	Churchill 1989 p. 36-37	Churchill 1989 p. 47-48	Churchill 1989 p.63-64	O'Neill & Jenkins 2001	Oetting 2005a	Havercroft 1985	Havercroft 1985	Havercroft 1985	Toepel & Bland	Total
Mesh Size	Unlisted	1/4"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"	1/4"	1/4"	Unlisted	
Peromyscus maniculatus	3													
Scapanus townsendi	7		1											
Cricetidae		43												
Sorex spp.	1	2												
Spermophilus spp.												4		
Aves														
Gallus gallus	1													
Anatidae	1													
Anserinae	3													
Branta canadensis	6													
Chen caerulescens	1													
Anas spp.	3													
Anas crecca		1												
Anas platyrhynchos		11												
Anas acuta	1													
Aix sponsa		1												
Accipitrinae	1													
Dendragapus obscurus		8												
Agelaius phoeniceus		12												

Sub-Drainage	Mid-Willamette	Upper Willamette	Middle Fork	Middle Fork	Middle Fork	Middle Fork	Middle Fork	S. Santiam	Upper Willamette	Upper Willamette	Upper Willamette	Upper Willamette	McKenzie	
Site	35-LIN-468	35-LA-218	35-LA-801	35-LA-802	35-LA-190	35-LA-191	35-LA-656	35-LIN-660	35-LA-1283	35-BE-10	35-BE-37	35-BE-39	35-LA-951	
Citation Page No.	Fagan et al 1996 Appendix	Toepel & Minor 1980 196-201	Churchill & Jenkins 1989 p. 101-110	Churchill & Jenkins 1989 p. 101-110	Churchill 1989 p. 36-37	Churchill 1989 p. 47-48	Churchill 1989 p.63-64	O'Neill & Jenkins 2001	Oetting 2005a	Havercroft 1985	Havercroft 1985	Havercroft 1985	Toepel & Bland	Total
Mesh Size	Unlisted	1/4"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/4"	1/4"	1/4"	Unlisted	
Fish														
Cyprinidae													2	
Catostomus spp.													1	
Reptilia														
Testudinidae		36												
Sceloporus occidentali						1								
Total	103	152	31	3	1	3	38	1	1	1	7	29	3	373
Number of species	24	15	10	1	1	2	8	1	1	1	1	5	2	

The distribution of faunal remains in Willamette Valley archaeological sites is highly uneven and patterned. With the exception of 35-LA-218, all sites with more than five identified faunal specimens were located in caves or rock shelters. This finding is consistent with Lyman's records for areas southwest of the Willamette Valley. The majority of identified faunal remains (255 out of 373) were located at two sites, 35-LIN-468 (Fagan et al. 1992) and 35-LA-218 (Toepel and Minor 1980). Seven of the remaining sites had less than five identified faunal specimens. Of the remaining four excavated sites with identified faunal remains, deer (*Odocoileus* sp.) is the most commonly identified taxon, as well as one of the most abundant, while the order Rodentia is the most common order represented (Table 2).

Of 13 sites with identified faunal remains, six could be located on the Oregon SHPO GIS system as site points (Table 3). An additional site (35-LA-656) was placed near Deadhorse Creek, based on information in the site report (Churchill 1989). The remaining six could not be isolated to a single point, since they were attributed to polygons that signified survey dimensions, which could stretch over many acres of land. Distance from the nearest river or large stream varied from 2300 m (35-LA-1283) to 220 m (35-LIN-468). It appears that, with the exception of 35-LA-802 and 1283, most of the sites with faunal remains are within walking distance, but not immediately adjacent to a place where salmon could have been exploited.

Table 3. Distance of Sites with Faunal Remains from a River

Site Number	Distance from River (and potential salmon source)
35-LIN-468	220 m from Calapooia River
35-LIN-660	252 m from Oak Creek, Tributary of South Santiam River
35-LA-190	469 m from tributary Middle Fork Willamette (Reservoir area, unable to determine original river location)
35-LA-191	572 m from tributary of Middle Fork Willamette (Reservoir area, unable to determine original river location)
35-LA-656	No site point in database. Very near Deadhorse creek (Churchill 1989)
35-LA-802	1048 m from Middle Fork Willamette River
35-LA-1283	2300 m from McKenzie River

Trends in Sub-Basin Data

In order to determine how excavation methods and volume excavated affect faunal representation, I analyzed the relationship between number of sites with faunal remains and total number of sites per sub-basin as well as total number of sites that listed mesh size and volume excavated per sub-basin. It is expected that as excavated volume increases, so should the number and variety of artifact types (Lyman 1995). This can be analyzed in two ways, first an increase in the total number of excavated sites in a region should suggest that more volume has been excavated than in regions with fewer sites. Second, if excavated volume is recorded, one could contrast either the total volume excavated from a region, or the mean volume per site in a region with the number of sites with faunal remains. In addition to volume, mesh size should have an effect on the number and variety of artifacts. As mesh size decreases, the number and variety of artifacts should increase

(Lyman 1995). In the succeeding section, I analyze which factors affect faunal representation in the Willamette Valley.

The distribution and number of sites with faunal remains is strongly related to the total number of sites tested in each of the Willamette Sub-basins (Figure 3, Table 4, R^2= 0.8041, p=0.0008). On the other hand, there is a weaker relationship between the number of sites that had been excavated using ¼" mesh screens, and had recorded the volume excavated versus the number of sites with faunal remains (Figure 4, R^2= 0.5359, p=.0558).

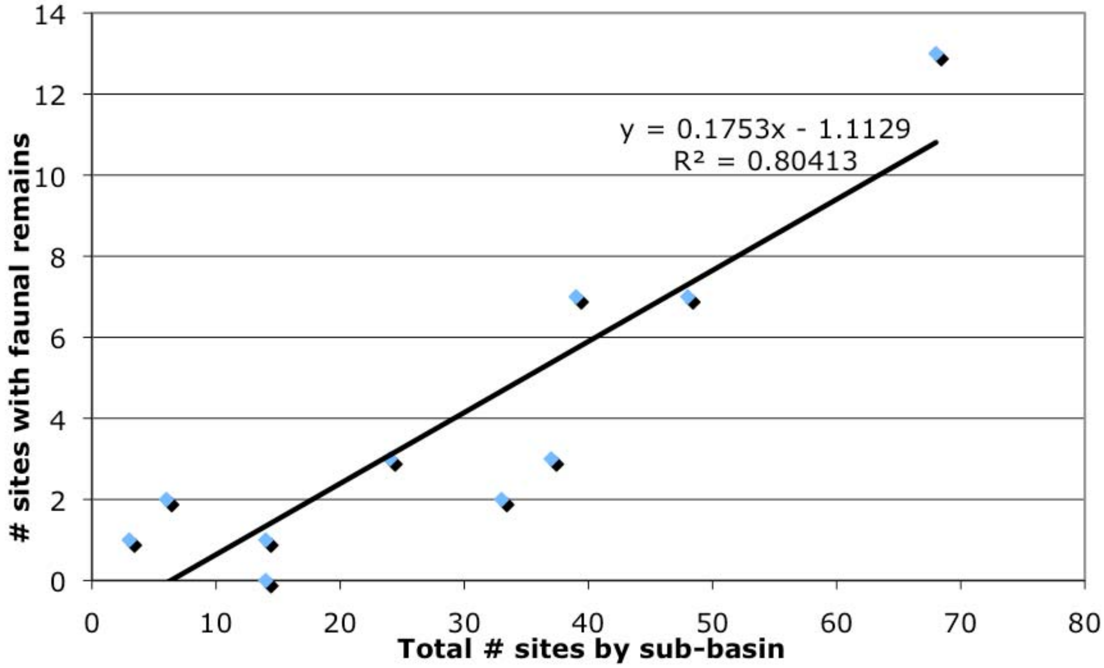

Figure 3. Relationship Between Number of Sites with Faunal Remains and Total Number of Sites by Sub-Basin

Table 4. Number of Excavated Sites vs. Number of Sites within Sub-basin with Faunal Remains

Sub-Drainage	# excavated sites	# sites with faunal remains
Mid Willamette	3	1
North Santiam	6	2
South Santiam	14	1
McKenzie	14	0
Coast Fork	24	3
Middle Fork	33	2
Molalla	37	3
Tualatin	39	7
Yamhill	48	7
Upper Willamette	68	13
Total	286	39

There is not a strong correlation (R^2= 0.5359, p=0.0558) between the number of sites that list volume excavated and used a mesh size less than or equal to ¼" versus the number of sites with faunal remains (Figure 4).

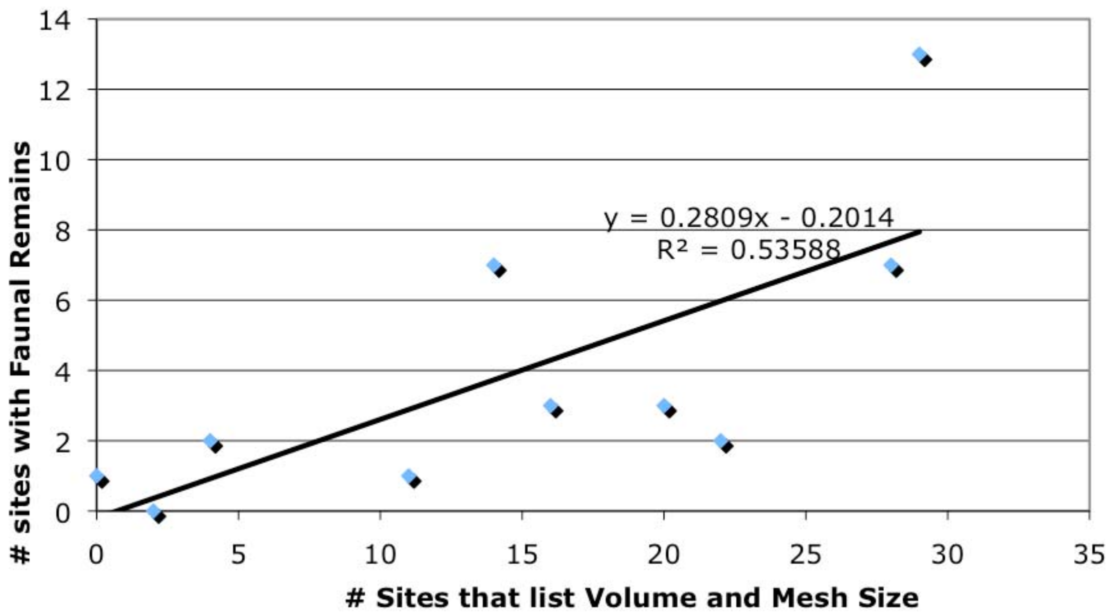

Figure 4. Relationship Between Number of Sites with Faunal Remains and Number of Sites that list Volume and Mesh Size

However, if excavation methods are not reported, this does not affect the outcome of the field methods themselves. Instead, it only affects another researcher's ability to interpret the effect of these methods on the outcome of the excavation.

Finally, there are many factors that affect whether faunal remains are identified, some of which have little to do with the methods used to excavate a site (budget constraints, staff qualifications, preservation). When I compared number of sites with identified faunal remains against number of sites, number of sites that listed volume excavated and ¼" or smaller mesh, number of sites with faunal remains, and mean volume excavated, all comparisons yielded a very weak correlation.

Overall, my analysis suggests that the factor that most strongly affects the number of sites with faunal remains in a particular sub-basin is the number of sites that have been excavated, an expected finding.

Discussion

Faunal remains are extremely rare in Willamette Valley archaeological sites. Thirty-nine sites (13.5%) have faunal remains, and only thirteen sites out of 286 (4.5%) had faunal remains that had been identified to the taxonomic level below class. Seven of these sites have five or fewer identified faunal remains. This leaves five sites, two in the Upper Willamette, one in the Mid-Willamette, and two in the Middle Fork of the Willamette with potentially enough faunal remains to assess whether salmon were used in the Willamette Valley. All five (35-LIN-468, 35-LA-281, 656, 801, 35-BE-39) of the remaining sites had remains from small and large mammals. Rat, gopher, squirrel, and mole made up the vast majority of small mammal bones. While ethnographic evidence that suggests that small mammals were used by the Native people of the Willamette Valley, it is difficult to determine whether these remains result from human exploitation or post-depositional intrusion. Only site 35-LIN-468 had a wide variety of small, medium, and large animals that clearly could not have been deposited after human use of the site.

The majority of sites with faunal remains (n=29, 69%) had faunal remains that were highly fragmented and could only be identified as “medium” or “large” mammals. This level of fragmentation could be related to post-depositional preservation issues, but it may also be the result of human use. Activities such as grease and marrow extraction involve the destruction of faunal remains, resulting in highly fragmented bone pieces (Lyman 1994). Human use, therefore, could play a role in bone preservation in this region.

Since there are so few sites with identified faunal material, and only one site (35-LIN-468) where it is clear that the variety of animal remains present is a direct result of human exploitation, my analysis shows that bone preservation in the Willamette Valley is quite poor, either resulting from natural or behavioral factors. With such a small sample size to analyze, and poor preservation of faunal materials, the Willamette Valley zooarchaeological record is unable to address whether salmon were used by the valley’s inhabitants.

Interestingly, while the people of the Willamette Valley are oftentimes portrayed as primarily root eaters based on the ethnohistoric (Coues 1897) and archaeological record (Aikens 1993), compilation of the Willamette Valley archaeological records revealed that there are fewer sites that note plant remains (23), than sites that note faunal remains (39). On the other hand, while only 14 out of 39 sites had faunal remains that were identified to a taxonomic family, all sites with plant remains had plants identified to a taxonomic family. The focus on plants in the Willamette Valley archaeological record may be because they are more commonly identified to a taxonomic level than faunal materials, and that the features associated with plant processing are more easily identified than fish capture or fish processing features.

Blood residue analysis from multiple sites in the North Santiam (35MA-105, 107, and 114) and mid-Willamette (35MA-451 and 470) drainages yielded positive results for trout residue, corresponding well with Jacob’s (1945) ethnographic informants describing salmon use by the Kalapuya of the North Santiam. Williams (1994:3) notes that most antisera used during blood residue analysis reacts only to animals that are within the family group of the control species specimen, a statement with which Fiedel (1997) disagrees (see below). Since salmon and trout belong to family Salmonidae, it is likely that both will elicit a reaction from trout antisera.

While blood residue analysis has been used as a tool in archaeological analysis for nearly 30 years, the reliability of this method has been repeatedly questioned (Reuther et al. 2006). Fiedel (1997) notes that many blood residue tests, including the one run by Williams, use a limited number of antiserum that approximate ethnographically utilized animals, rather than antisera from a variety of animals. Past research has shown that some serums have the potential to cross-react with the antiserum of other species (Fiedel 1997, Reuther et al. 2006). Fiedel further argues that without blind tests, which tests blood residue from lithics against a variety of animal residues, including animals that are not expected, blood residue results should be looked at skeptically. Williams (1994) addresses this issue through pre-screening antiserum samples with non-immune serum to determine whether the sample is reacting to non-specific proteins. Whether this was an effective method to deal with cross-reactivity is not addressed in any recent publications. That Reuther et al. (2006) are discussing ways to increase the accuracy of protein residue analysis nearly twelve years after Williams' publication, however, suggests that there are still doubts about the effectiveness of blood residue analysis.

Chapter 4: Using the Diet Breadth Model from Optimal Foraging Theory to Examine Salmonid use in the Willamette Valley

As considered in previous chapters, the ethnology and archaeological records are limited in their ability to evaluate whether Native peoples of the Willamette Valley relied on salmon for subsistence. The ethnographic record, while helpful for determining what was consumed, is too incomplete to be used to determine what was not consumed. Faunal remains in the archaeological record are scarce, and the sample size too small to draw conclusions about subsistence practices. An alternative way to consider Native American resource use draws on models from optimal foraging theory, a branch of Human Behavioral Ecology. Human Behavioral Ecology (HBE) is a quantitative approach, which assumes that organisms, in this case humans, will respond to their conditions (social and environmental) in fitness enhancing ways (Smith and Winterhalder 2003: 378). Using this framework, one can predict the optimal diet (diet breadth) in a given region based on associated archaeological, ethnographic and/or ecological data, and various assumptions about return rates of plant and animal resources.

Diet breadth analysis in the Willamette Valley has at least three benefits. It can generate expectations about human behavior in situations for which ethnographic and/or archaeological data are scarce. These expectations can be used as a frame of reference with which to assess existing data and common sense perceptions of subsistence in the Willamette

Valley. Finally, targeted research questions can be generated when incongruities are found between expected subsistence practices and archaeological or ethnographic records for subsistence practices.

Using the diet breadth model, this project will test whether salmon exploitation would have been a viable option for the people of the Willamette Valley given the availability of a variety of resources. If the diet breadth analysis predicts that salmon should have been exploited, I analyze whether there are regional factors which lower the relative rank of salmon, such as lack of availability or increased search or processing time associated with salmon capture. To do this, I describe the resources that are known to have been used in the region, then briefly summarize optimal foraging theory. After this, I present return rate data based on ethnographic records relating to subsistence and the hypothetical addition of salmon. Once these data are presented, I assess whether salmon would have been a viable resource, based on the results of the diet breadth analysis and other factors. Finally, the results of this analysis shows that while salmon exploitation was probably not as profitable as in other areas in the Pacific Northwest, the resource should still have been exploited given its relatively high rank.

Human Behavioral Ecology

HBE draws its theoretical underpinnings from evolutionary theory, micro-economics, and game theory. HBE research is applied by predicting the optimal behavior at the level of the individual (Smith and Winterhalder 2003:

378) for a given region and then comparing it to actual behavior. Using this process, one assumes that the organism in question is rational, will optimize its strategy, and prefers evolutionary stable strategies (Smith and Winderhalder 2003: 378). HBE is most commonly applied to issues relating to subsistence in the form of optimal foraging models. Like any other model in HBE, optimal foraging models include a goal, currency, a set of constraints, and a set of options (Kelly 1995:73). Generally, the goal of most models is to maximize foraging efficiency. However, some argue that subsistence strategies are not necessarily maximally efficient, but rather efficient enough for the purposes of the forager. This behavior is called sufficing. The currency for most foraging models is energy, as measured in calories. Constraints can include time, distance, and number of exploitable resources (Kelly 1995:73). The number of exploitable resources also represents the universe of potential exploitation options.

The prey choice, or diet breadth model is designed to predict which food items will be exploited and ignored by foragers. Energy costs in this model include searching and handling, which includes pursuit, capture, and processing for a given food item. This cost is measured by the variable “time”, and is considered when calculating caloric gain achieved by exploitation of the resource. Food preference is based upon the net energy return rate from a resource (Kaplan and Hill 2008:169). Only when the resource with a high return rate is depleted, or the return rate declines, will the next highest rated resource be selected. The optimal diet would include resources that have a higher return rate than the mean return rate for all possible resources available to the forager (Kaplan and Hill 2008:171). To use this model, it is assumed that searching and handling are mutually exclusive activities, prey are encountered sequentially and randomly, but proportional to their abundance, prey types are not systematically clumped or evenly dispersed, foragers have no impact on resource abundance, and finally, the forager can estimate mean encounter rates, energy returns, and handling costs of resources (Kaplan and Hill 2008:169). It is also important to note that this model will predict diet breadth, but this diversity can change over time (Kelly 1995:87), as some resources are only seasonally, or intermittently, available. For example, in parts of the Great Basin culture area, return rates for grasshoppers range from 41,598 kcal /hr to 714,409 kcal/hr during various and unpredictable intervals in the summer (Madsen and Kirkman 1988:600-601).

Madsen and Kirkman (1988) and Simms (1985), among others, have used the diet breadth model to quantify the return rate of a variety of resources for hunter-gatherers after pursuit and processing time have been taken into account. From these data, researchers have constructed models of resource use. It is through these models, that researchers have determined that cost of processing, as well as resource abundance, affects its rank (Jones and Madsen 1989).

In order to build a diet breadth model, one needs to compile a list of available resources and estimate their rate of return. Prior to estimating return rate, one must decide whether they want to simply present the yield associated with a resource, or a post-processing return rate, which takes factors such as search and handling time into account. In the following section I will estimate the post-processing return rate of the resources available to the Native people of the Willamette Valley.

Methods and Materials

The subsistence behaviors of native peoples observed by ethnographers and Euro-American explorers will be used as a starting point for my model on the Willamette Valley. Zenk (1990:547) reports vegetable resources were a major portion of Kalapuyan subsistence. As noted in Chapter 2, of particular importance is camas. Wapato (*Sagittaria latifolia*), tarweed (*Madia sativa*), hazelnut (*Corylus spp.*) and berries (e.g., *Rubus* spp. and *Vaccinium* spp.) are also believed to have been commonly used plant resources. Acorns (*Quercus garryana*) were exploited, but considered to be of lesser importance than the above-mentioned resources. Animal resources included duck (*Anas* spp.), small mammals (gophers, squirrels, hares) deer (*Odocoileus* spp.), elk or wapiti (*Cervus elaphus*), black bear (*Ursus americanus*), grasshoppers (order Orthoptera), lamprey (*Lampetra* spp.), and caterpillar (Division Ditrysia) (Zenk 1990:548). I have enlarged the list of taxa from Zenk's list to include Chinook salmon to address whether they would have been considered a viable resource, since they are available in the region (Table 5).

Table 5. Willamette Valley Resources Considered for Optimal Foraging Model, Based on Zenk (1990)

Latin Name	Common Name
Sagittaria latifolia	Wapato
Madia sativa	Tarweed+
Corylus spp.	Hazelnut
Rubus spp.	Blackberries, raspberries+
Vaccinium spp.	Blueberries, huckleberries+
Quercus garryana	Oak (Acorns)
Camassia quamash	Camas
Odocoileus spp.	Deer
Cervus elaphus	Elk, Wapiti +
Ursus americanus	Black Bear +
Order Rodentia	Rodents (eg. gophers, hares, ground squirrels)
Anas spp.	Ducks
Lampetra spp.	Lamprey+
Oncorhynchus tshawytscha	Chinook salmon
Division Ditrysta	Caterpillar*+
order Orthoptera	Grasshoppers*+

+ Excluded from model owing to lack of information
*Excluded from model because resource was likely minor

If possible, I used caloric return rates based on data from or near the Willamette Valley. If this was not possible I included records from other regions. If return rates were not available for a given resource, I estimated values using ethnographic sources. If none of this information was available for a resource, it was excluded from analysis. I was unable to find nutritional or ethnographically described capture and processing times for elk, black bear, lamprey, tarweed, *Rubus* and *Vaccinium* berries, and caterpillars, and thus these were excluded. I realize the limitations their omission may create and I will consider these below. Details on return rates can be found in the relevant references listed in Appendix B.

In addition to omitting resources for which I could not obtain return rate information, I also omitted post-processing return rate estimations that clearly did not represent the regional abundance of a given species. For example, grasshoppers were excluded form the study for two reasons. First, the only available return rates were from Desert Basin in Utah, conditions drastically different from the Willamette Valley. Second, while Zenk mentions their use, grasshoppers are not abundant in mass such as in the Great Basin and were likely not an important resource in the Willamette Valley.

I used caloric return information for *Odocoileus hemionus* to represent deer (*Odocoileus* spp.) in the Willamette Valley, even though two species are located within the Valley. I did this because; 1) both deer species are comparable in size, and 2) I could not find caloric return information for the second species of deer.

One potential problem with my modeling effort relates to a lack of clarity regarding the assumptions and methods used to calculate post-processing return rates. Thoms (1989), Darby (1996) and Lindström (1996) created their own post-processing return rate estimates, with their steps and assumptions included, while Simms (1985) and Kelly (1995) used data relating to return rates that were compiled in other reports. Since there is no mention of how return rate was calculated, or of the methods used to calculate in Simms' and Kelly's work, I cannot be sure that the methods used and assumptions made are comparable. I will, for the purpose of this exercise, assume that the presented post-processing return rates are not net energy acquisition rates, which does not take pursuit or processing costs into account. When it is necessary for me to calculate post-processing return rates, I will use Equation 1:

Equation 1

$((Kcal \times Kg_t)/Ic)/((t + pt)/Ip) = PPR.$

Where, t = the timeframe (in hours) in which collecting activities took place,
Kg_t = the amount of resources collected (in kg) during "t",
Kcal = kilocalories derived from 1 kg of a given resource,
pt = the amount of time needed to process "Kg_t",
Ic = number of individuals associated with collection activities,
Ip = number of individuals associated with processing activity,
PPR = post-processing return rate (in kcal/hr) for an individual.

This equation differs slightly from Smith and Winterhalder's (2008:170), in that I explicitly accounted for the number of people associated with collection and processing activities, as reported in ethnographic sources, to generated post-processing return rate for an individual. I did this by dividing the total number of calories extracted from a resource over a given period of time (Kcal x Kg_t) by the number of individuals (Ic) associated with this collection activity. If I did not know the number of individuals, I assumed that one individual participated in the activity. I used the same method to determine total processing time for each individual associated with processing.

I could not find published post-processing return rate data on native hazelnut, and therefore estimated this value using harvesting estimates by Reidhead (1980) for the hazelnut species *Corylus avellan,* which potentially differs from the native hazelnut variety. Nutritional values were drawn from the USDA (2009) nutrition value website. Since I could not find data relating to ethnographic processing practices, I assumed negligible processing time, since processing time would consist of cracking the shell to remove the meat, but viewed the results as a rough approximation of caloric returns from hazelnuts given this assumption (Appendix C: Hazelnut Return Rate).

To estimate post-processing return rates for salmon, two sources were available. One was Susan Lindstrom's ethnographic records for salmon fisheries of the Truckee River of the Western Great Basin. A second was from Charles Wilkes, from his observations of fishing at Willamette Falls. I decided to use Wilkes, given the proximity to the research area. For method of salmon capture, I used Jacob's (1945:31) observations that the Kalapuyan people used spears to capture salmon and steelhead. Equipment manufacture and processing times for fish were calculated using estimates from Great Basin ethnographic records (Lindström 1996, Appendix D: Chinook Salmon Return Rate at Willamette Falls).

It is unlikely that fish exploitation was as productive above the falls as it was at the falls, given that there are few rapids or choke points from which to capture salmon with the use of nets. It is necessary, then, to consider how caloric return rates on salmon would have changed as the point of exploitation moved upriver of the falls. The main difference between a location with a choke point (eg. rapids or the falls) and a location without (above the falls) is the return rate on salmon. This change, however, profoundly affects how salmon are ranked. Because salmon capture records were not available from locations above Willamette Falls, I calculated salmon return rates using ethnohistorical seine fishing catch records in the Snake River in 1894 as cited in Plew (1983). Calculations used to determine Chinook salmon return rates above Willamette Falls can be found in Appendix E.

Finally, when salmon are captured, they can be eaten fresh immediately, or dried, stored and eaten at a later date. Through the process of drying and storing, some of the nutritional value is lost (Plew 1983). In addition, preparing salmon for storage (including processing, drying, and storing), takes more processing time than for fresh salmon. It is, therefore, necessary to calculate the return rate of both fresh and dried salmon.

There is another factor, other than spatial location, that affects a resource's ranking. Resources such as migratory birds, plants, and fish can only be exploited during specific seasons. In the Willamette Valley, the availability of many resources is highly dependent upon seasonality.

Therefore, calculating and collecting caloric return rates alone would not have been enough to understand the logistical factors that affect resource use in the Willamette Valley. Information on the seasonality of resources is also necessary to understand resource availability over a year. As a result, I also collected information relating to the season in which the various resources were collected. Once this was complete, the twelve month cycle was divided into two-month increments and then I examined the relative rank of resources that would have been exploited during each time segment.

Results

Of the 16 varieties of resources that are known ethnographically to have been used by Native peoples of the Willamette Valley, I obtained enough information to calculate post-processing return rates for nine. These resources included camas, wapato, deer, oak, *Anas* spp. (ducks and geese), rodents (ground squirrels, gophers, hares, salmon, hazelnut, and grasshoppers (Table 6).

As stated above, resource seasonality needs to be considered to better understand when resources would have been available. As shown in Table 6, some resources are available year round, while others are highly seasonal. Generally, floral resources from this region were harvested from late summer to fall. Wapato was the exception, and was harvested from late fall to early spring. With the exception of salmon, there was no mention of the seasonality of faunal resources in the ethnographic literature. There was no overlap between the periods where Chinook salmon would have been exploited and the periods when camas would have been exploited. There may have been a slight overlap between the end of the wapato harvest and the beginning of the period when salmon could have been harvested.

Table 6. Willamette Valley Resource Availability in Bi-Monthly Segments

Species (Common name)	January/ February	March/ April	May/ June	July/ August	September/ October	November/ December
Corylus spp ((Hazelnut)					X	
Quercus spp. (Oak, acorn)				X	X	
Anas spp. (Ducks)	X	X	X	X	X	X
Sagittaria latifolia (Wapato)	X	X			X	X
Camassia quamash (Camas)				X	X	
Spermophilus spp. (Squirrels)		X	X	X		
Lepus spp. (Hares)	X	X	X	X	X	X
Geomyidae (Gopher)	X	X	X	X	X	X
Odocoileus spp. (Deer)	X	X	X	X	X	X
Oncorhynchus tshawytscha (dry) (Chinook Salmon)		X	X			
Oncorhynchus tshawytscha (fresh) (Chinook Salmon)		X	X			

In the vicinity of Willamette Falls, between early spring and early summer when the fish arrived at the falls, Chinook salmon would have been the highest ranked resource whether eaten fresh or dried (Table 7, Table 8).

Table 7. Types and Post-Processing Return Rate of Resources near Willamette Falls, Averaged for Whole Year

Name	Mean Value (kcal)
Oncorhynchus tshawytscha (fresh)	87441.37
Oncorhynchus tshawytscha (dried)	35635.87
Odocoileus hemionus	24710.5
Geomyidae	9881.5
Lepus spp	9391.5
Spermophilus spp.	5865.5
Sagittaria latifolia	3240
Anas spp.	2342
Quercus spp.	2075
Camassia quamash	2042
Corylus spp	492

Table 8. Resource Rank in Bi-Monthly Segments at or near Willamette Falls

Rank	January/ February	March/ April	May/ June	July/August	September/ October	November/ December
1	Odocoileus hemionus	Oncorhynchus tshawytscha (fresh)	Oncorhynchus tshawytscha (fresh)	Odocoileus hemionus	Odocoileus hemionus	Odocoileus hemionus
2	Geomyidae	Oncorhynchus tshawytscha (dry)	Oncorhynchus tshawytscha (dry)	Geomyidae	Geomyidae	Geomyidae
3	Lepus spp.	Odocoileus hemionus	Odocoileus hemionus	Lepus spp.	Lepus spp.	Lepus spp.
4	Sagittaria latifolia	Geomyidae	Geomyidae	Spermophilus spp.	Sagittaria latifolia	Sagittaria latifolia
5	Anas spp.	Lepus spp.	Lepus spp.	Anas spp.	Anas spp.	Anas spp.
6		Spermophilus spp.	Spermophilus spp.	Quercus spp/	Quercus spp.	
7		Sagittaria latifolia	Anas spp.	Camassia quamash	Camassia quamash	
8		Anas spp.			Corylus spp.	

In periods when salmon was not available, deer and small mammals would have been the highest ranked resources. Camas achieves its highest rank (7th) during the period of September/October, while wapato achieves its highest rank (4th) during the periods of November/December and

January/February. Small mammals and ducks are consistently a middle to upper-middle ranked resource throughout the year.

Above Willamette Falls, deer is the highest, and Chinook salmon is the second highest ranked resource in the region when seasonality is not considered (Table 9). Fresh salmon would have been the second highest ranked resource if seasonality is taken into account (Table 10). Dried salmon drops to the fifth highest ranked resource during the period when salmon would have been exploited. Small mammals and ducks are consistently middle to upper-middle ranked throughout the year.

Table 9. Types and Post-Processing Return Rate of Resources above Willamette Falls

Name	Mean Value (Kcal)
Odocoileus hemionus	24710.5
Oncorhynchus tshawytscha (fresh)	15457.5
Geomyidae	9881.5
Lepus spp	9391.5
Oncorhynchus tshawytscha (dried)	8583.5
Spermophilus spp.	5865.5
Sagittaria latifolia	3240
Anas spp.	2342
Quercus spp.	2075
Camassia quamash	2042
Corylus spp.	492

Table 10. Resource Rank in Bi-Monthly Segments above Willamette Falls

Rank	January/ February	March/ April	May/ June	July/ August	September/ October	November/ December
1	Odocoileus hemionus	Odocoileus hemionus	Odocoileus hemionus	Odocoileus hemionus	Odocoileus hemionus	Odocoileus hemionus
2	Geomyidae	Oncorhynchus tshawytscha (fresh)	Oncorhynchus tshawytscha (fresh)	Geomyidae	Geomyidae	Geomyidae
3	Lepus spp.	Geomyidae	Geomyidae	Lepus spp.	Lepus spp.	Lepus spp.
4	Sagittaria latifolia	Lepus spp.	Lepus spp.	Spermophilus spp.	Sagittaria latifolia	Sagittaria latifolia
5	Anas spp	Oncorhynchus tshawytscha (dry)	Oncorhynchus tshawytscha (dry)	Anas spp.	Anas spp	Anas spp.
6		Spermophilus spp.	Spermophilus spp.	Quercus spp.	Quercus spp	
7		Sagittaria latifolia	Anas spp.	Camassia quamash	Camassia quamash	
8		Anas spp			Corylus spp.	

Discussion

Based on the results of diet breadth analysis, spring Chinook salmon are the highest ranked resource at Willamette Falls, and the second highest ranked resource above Willamette Falls, when they are captured and consumed fresh in the late spring and early summer. Salmon's availability does not coincide with camas availability, and may intermittently coincide with wapato availability.

Plant foods tend to be low ranked resources for all seasons, which is expected. In addition to their low rank, plant foods also tend to be highly seasonal in availability.

While Chinook salmon are highly ranked resources throughout the Willamette Valley, and the highest ranked resource at Willamette Falls, deer are the highest ranked resource in the Willamette Valley, above Willamette

Falls, which represents much of the region. In addition, while salmon would have been highly ranked when available, their availability was patchy both in time and space. Deer, by comparison, would have been available year-round.

While intriguing, this modeling effort has limitations. I was able to estimate post-processing return data for nine of 16 resources in the Willamette Valley. Based on this incomplete sample, salmon are highly ranked when available. Their availability, however, is limited to specific locations at specific times. Plants share this constraint, but may have the advantage of being easier to process for long-term storage. Deer, ducks, and small mammals were available year-round, and in all areas above Willamette falls, deer are the highest ranked resource throughout the year. The combination of limited availability in time and space and the presence of other highly ranked resources year round may affect how the native peoples of the Willamette Valley viewed salmon as a resource.

Chapter 5. Discussion and Conclusions

The goal of my thesis was to determine whether the regional archaeological record is adequate for assessing salmon use in the Willamette drainage, and to explore whether salmon would have been a viable resource for exploitation. To do this, I synthesized aspects of the regional archaeological record to determine whether salmon were used, and if the regional faunal sample was sufficient to rule out their use if salmon remains were not found. In addition, the diet breadth model was used to test whether salmon exploitation would have been a viable option for the people of the Willamette Valley given the availability of a variety of resources.

My work demonstrates there are very few sites with identified faunal material, and only one site (35-LIN-468) with a variety of animal taxa present resulting from human exploitation. Faunal remains are extremely rare in Valley sites. Thus the scarcity of fish remains could simply be a function of the overall scarcity of bone, rather than signify anything about past human activities. The Willamette Valley zooarchaeological record inadequately addresses whether salmon was used by the people of the Willamette Valley.

Blood residue analysis from five sites yielded positive results for trout residue. However, there is clearly still debate about the validity of blood residue analysis. Therefore, these data may indicate that trout or salmon were collected above Willamette Falls, as well as provide a harvest location, but until there is greater agreement about the validity of blood residue analysis, it cannot be used as a strong line of evidence.

Diet Breadth

While the results of my diet breadth analysis show that salmon would have been a very highly ranked resource in the region, it is important to recognize that this model is based on assumptions about gear and harvesting rates from areas outside of the Willamette Valley, including the Snake River and the Western Great Basin (Plew 1983, Lindström 1996). Factors such as salmon run size, ease of capture, and methods used for capture, all of which affect post-processing return rate, may have varied from that which occurred in the Willamette River. As a result, the reported post-processing return rate is a rough approximation of what the caloric value of salmon was in this region. Additionally, the breadth of resources used for this analysis was limited both in the detail and variety of the ethnographic and archaeological datasets, as well as by the limited amount of data about resources that are known to have been used in the region, and will be discussed below. In addition, if more plant resources were used than reported, or if the values for known resources were included in the model (eg. berries, tarweed), then it is likely that the mean caloric value for the full range of resources would decrease. Darby (1996) argues against the assumption that all foods are ranked by the same currency.

Salmon provide a large amount of protein, but few carbohydrates. Geophytes, by comparison, provide large amounts of carbohydrates but little protein. It is likely that lower ranked resources would be selected for their carbohydrate value rather than their caloric value alone.

I could not find post-processing return rate information for seven resources, including elk, black bear, lamprey, tarweed, *Rubus* and *Vaccinium* berries, and caterpillars. While this does not necessarily negate the value of the model, which is to demonstrate that salmon were highly ranked resources, it does mean their relative rank could have been lower than what was observed in the model. For example, it is likely that, above Willamette Falls, elk would have been ranked higher than salmon given their great body size, and the high cost of salmon procurement.

In order to get a more concrete idea of what salmon's relative rank would have been in the Willamette Valley, it is necessary to consider the environmental factors that may have affected salmon availability. Schalk (1986:13) argues that seasonal variations in river height and waterfall volume affected the vertical distance that the fish need to jump to ascend the falls. During periods where a high volume of water is expelled over the waterfall and the river is high, the vertical distance may be half that of the falls during the dry season, which extends between July and October (Zenk 1976). As a result, fish may only have been able to ascend the falls in the spring and summer. This observation is supported by Fulton (1968:18), who notes that Willamette

Falls “probably always blocked fall chinook salmon.” The combination of a single salmon season, and potentially unpredictable falls passage may have had two effects on salmon abundance and, in turn, human decision making about resource selection. First, salmon may not have been a predictable enough resource to have been sought after; geophytes, on the other hand met these conditions. Second, the number of salmon that could ascend the falls may have been too low to exploit in any meaningful number, which is the condition for intensifying gephyte exploitation in Thoms’ (1989) model.

Once spring Chinook salmon ascend the falls, they are not evenly distributed throughout the Willamette River and its tributaries. Therefore, even if, as Fulton notes (1968, 1970), the Willamette has “substantial” stocks of salmon during the spring run, these runs would be limited to the mainstem Willamette River and its eastern tributaries.

Another factor that would have affected salmon’s ranking relative to other resources is storage potential. Schalk (1986:13) notes that fall salmon are better suited for storage purposes than the spring run salmon since the latter have high oil content, and their arrival precedes the hottest months of the year, making drying and storage difficult. In the larger Pacific Northwest region, the fall run was generally preferred for drying and smoking (Schalk 1986:13). Following Schalk’s reasoning based on ethnographic analysis, unlike other peoples of the Pacific Coast and the Columbia River who caught, dried, and stored salmon for year-round consumption, the native peoples of the Willamette Valley would have relied on spring salmon as a fresh resource, not for preservation.

Considering storage and transportation, the Kalapuyans used baskets and had canoes (Zenk 1990) and stored camas and wapato. Therefore, technologically at least, the Native People of the Willamette Valley had the capacity to transport and store large quantities of salmon. Kaplan and Hill (2008: 186) argue that when foragers are collecting resources from a patch, and transporting them back to their place of residence, they should collect resources that yield the highest amount of calories per basket load. If this argument is applied to salmon vs. any plant resources, salmon should be selected. However, the only plant resource collection activity that may have occurred during the same period as the spring run of salmon would have been wapato, which grows in lakes and rivers, one of which is the same environment where salmon could be found. Considering transportation distance, Thoms (1989:302) reports that the Native people of the Willamette Valley wintered on relatively high ground, but moved closer to the river during the spring and summer. This suggests that the people of the Willamette Valley would not have had to transport salmon far by land.

Overall, Fulton's (1968, 1970) data suggests that the Willamette River ecosystem had the capacity to support "substantial" amounts of salmon above the falls, which means that there was no environmental reason that the spring salmon run was not exploited. On the other hand, stream discharge and size affected salmon distribution above Willamette Falls. This means that the smaller rivers with low discharges (e.g. Molalla and Tualatin) would have had smaller runs than larger rivers (e.g. North and South Santiam). This suggests that while salmon would have been abundant where they were available, their availability was likely patchy.

In sum, even if salmon were not as abundant in the Willamette Valley as in other areas of the Pacific Northwest, or if the time of their arrival did not coincide with the optimal time for fish processing and storage, fresh salmon was a very highly ranked resource that could be exploited predictably. Additionally, spring Chinook salmon would have been available just after wapato harvest between fall and late spring, and long before the camas harvest in late summer and fall, which suggests that it would not have conflicted with collection of resources that are known to have been extensively used.

Conclusion

My thesis challenges a commonly held stereotype that the Indigenous people of the Willamette Valley were strictly root eaters, and the basis for this claim, that salmon were not part of Native subsistence. First, given the incomplete nature of the ethnohistoric record, very little can be said about expected cultural behaviors, such as salmon consumption, that appear to be absent in the Willamette Valley. Second, since the faunal assemblage is so small in the Willamette Valley, zooarchaeological data are simply inadequate for studying the relationship between prehistoric peoples and their animal resources. Third, optimal foraging modeling suggests that salmon is one of the higher ranked resources available to the Native People of the Willamette Valley. The Willamette River sustained substantial stocks of salmon, whose availability coincides with a season when other known intensively used resources were not being harvested. As a result, there is no ecological reason that salmon would not have been exploited by the Native People of the Willamette Valley.

In order to test the expectations posed by this model, future work will need to integrate other types of archaeological remains (eg. fishing-related tools, residue analysis), since faunal remains are rare. Residue analysis has potential, but there is still debate about the validity of its results. These concerns need to be addressed prior to wide scale implementation.

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Appendix A. Summary of all Cultural Resource Reports with Excavation within Willamette Valley, as of June 2009

SHPO Bib #	**Site #**	**Site Name**	**Location**	**Author**	**Year**	**Page #**	**Data Collection Method**	**Mesh Size**	**Unit of Measure**	**Faunal table**	**Faunal Remains**	**Salmon Identified**	**Botanical Remains**	**Radiocarbon Dates**	**Fishing Gear**	**Surface Area (square meters)**	**Volume (cubic meters)**
8970	**18-03-186**	-	S. Santiam	Cole	1987	5-18	Square test units and Excavation	1/4"	Unlisted	No	No	No	No	No	No	.5	.2
8970	**18-03-187**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	1.75	.875
8970	**18-03-188**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	1	.4
8970	**18-03-189**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	1	.6
8970	**18-03-190**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	2.75	1.65
8970	**18-03-191**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	1	.5
19513	**25-LA-1228**	-	Coast Fork	Cabebe	2005	9, 13-17	Test Pits (50x50)	1/8"	Unlisted	No	No	No	No	No	No	1	.5
12825	**35-BE-10**	-	Upper Willamette	Havercroft	1985	74-77, 100-111	Excavation	1/4"	Count	Yes	Yes	No	No	Yes	No	10	Unable to Determine
12825	**35-BE-37**	-	Upper Willamette	Havercroft	1985	74-77, 82-99	Excavation	1/4"	Count	Yes	Yes	No	No	No	No	28	Unable to determine
12825	**35-BE-39**	-	Upper Willamette	Havercroft	1985	74-77, 112-124	Excavation	1/4"	Count	Yes	Yes	No	No	No	No	12	Unable to Determine
15904	**35-BE-51**	-	Upper Willa	Rogers	1996	9-21	Shovel Probes	1/8"	Unlisted	No	No	No	No	No	No	4.75	2.37

			mette														
19036	**35-BE-64**	Cool Guy Russ	Upper Willamette	Roth, Bird, and Broyles	1999	6-18	Excavation Unit	1/4"	Unlisted	No	No	No	No	No	No	23.75	15.075
19036	**35-BE-65**	Lara Gayle	Upper Willamette	Roth, Bird, and Broyles	1999	18-29	Excavation Unit	1/4"	Unlisted	No	No	No	No	No	No	25	12.55
13032	**35-CL-122**	-	Molalla	Fagan et al.	1992	133-135	Auger, Shovel Probe, Excavation	1/8"	Unlisted	No	Yes	No	No	No	No	Unlisted	Unlisted
15016	**35-CL-200**	-	Molalla	Roulette and Reese	1995	3-11	Excavation	1/8"	Unlisted	No	No	No	No	No	No	2	Unlisted
15243	**35-CL-223**	-	Tualatin	Wilt and Ellis	1996	1-9	Excavation	1/8"	Unlisted	No	No	No	No	No	No	2	1.2
16456	**35-CL-223**	-	Tualatin	Ellis	1998	4-7	Quarter test units	1/8"	Unlisted	No	No	No	No	No	No	4.5	2.6
2392	**35-DO-13**	-	Mid-Willamette	Pettigrew	1980	2-12	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	4	Unlisted
10235	**35-LA_801**	Pepper Rockshelter	Middle Fork	Churchill and Jenkins	1989	17, 23-45	Excavation	1/8"	Count	Yes	Yes	No	Yes	Yes	No	Unlisted	1.2
14582	**35-LA-1020**	Lookout Boatramp	McKenzie	Bergland	1994	1-11	Test Units and Test Probes	1/4"	Unlisted	No	No	No	No	No	No	5	2.0625
15329	**35-LA-1020**	-	McKenzie	Oetting	1994	13-37	Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	3.75	2.2
16980	**35-LA-1023**	Log	McKenzie	Southard	1999	16-21	Excavation Units	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	81	Unable to Determine
14187	**35-LA-1026**	Schied Rockshelter	Middle Fork	Oetting	1993	21-46	Excavation	1/8"	Unlisted	No	Yes	No	No	Yes	No	2	1.83
17325	**35-LA-1098**	Marksman	McKenzie	Southard	2000	7-32	Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	3	.9

13934	**35-LA-1116**	-	McKenzie	Bergland	1993	1-3	Test Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	2.75	1.375
15329	**35-LA-1125**	-	McKenzie	Oetting	1994	13, 38-56	Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	1.75	.675
15329	**35-LA-1128**	-	McKenzie	Oetting	1994	13-37	Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	3.25	1.725
15329	**35-LA-1129**	-	McKenzie	Oetting	1994	13-37	Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	.75	.35
19513	**35-LA-1187**	-	Coast Fork	Cabebe	2005	9-12	Test Pits (50x50)	1/8"	Unlisted	No	No	No	No	No	No	3	1.2
16501	**35-LA-1188**	-	Coast Fork	Boersema and Musil	1998	3-10	Shovel Test Probe	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to determine
16389	**35-LA-1202**	-	Middle Fork	Steffen and Winkler	1998	3-8	Shovel Test Units (50 x 50)	1/8"	Unlisted	No	No	No	No	No	No	8.25	Unlisted
17684	**35-LA-1223**	Natron	Middle Fork	Wilt, Roulette, and Hodges	2001	13-23	Shovel Test Pits and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	2.75	1
16984	**35-LA-1228**	Papenfus	Coast Fork	Tasa and Connolly	2000		Shovel tests, Excavation	1/8"	Unlisted	No	Yes	No		Yes	No	11.5	4.1
19513	**35-LA-1231**	-	Coast Fork	Cabebe	2005	9, 17-21	Test Pits (50x50)	1/8"	Unlisted	No	No	No	No	No	No	5.25	1.2

18741	**35-LA-1240**	-	Upper Willamette	Baker, Ellis, and Ozbun	2004	3, 8	Round Shovel Probes, Square Shovel Probes, Auger Test	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
19154	**35-LA-1261**	-	McKenzie	Oetting	2002	1-8	Shovel probes (round and square) and excavation	1/8"	Unlisted	No	No	No	No	No	No	30.3	12.9
19155	**35-LA-1276**	-	McKenzie	Oetting	2004	1-7	Shovel probes (round and square)	1/8"	Unlisted	No	No	No	No	No	No	3.5	2.1
18741	**35-LA-1278**	-	Upper Willamette	Baker, Ellis, and Ozbun	2004	3, 7	Round Shovel Probes, Square Shovel Probes, Auger Test	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
18741 20280	**35-LA-1280**	-	Upper Willamette	Baker, Ellis, and Ozbun	2004	3, 8	Round Shovel Probes, Square Shovel Probes, Auger Test	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
	35-LA-1283	-	Upper Willamette	Albert C. Oetting	2005a	12-31	Round Shovel Probes, Square Shovel Probes	1/8"	Unlisted	No	Yes	No	Yes	No	No	Unable to Determine	1.4

18741	**35-LA-1286**	-	Upper Willamette	Baker, Ellis, and Ozbun	2004	3-6	Round Shovel Probes, Square Shovel Probes, Auger Test	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
19597	**35-LA-1289**	-	Coast Fork	Cabebe	2004	8-13	Test Pits (50x50)	1/8"	Unlisted	No	No	No	No	No	No	1	.85
20898	**35-LA-1309**	-	Upper Willamette	Baker et al	2006	13-32	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	3	.4
5209	**35-LA-133**	Hobby Field	Coast Fork	Baxter and Swift	1983	6-11	Test Pit and Augering	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to determine
8471	**35-LA-149**	-	Upper Willamette	Baxter and Minor	1987	8, 18-20	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	1	.5
10533	**35-LA-190**	Olsen 1	Middle Fork	Churchill	1989	19, 29-37	Excavation	1/8"	Count	Yes	Yes	No	Yes	No	No	Unlisted	.25
10533	**35-LA-191**	Olsen 2	Middle Fork	Churchill	1989	19, 38-48	Excavation	1/8"	Count	Yes	Yes	No	Yes	Yes	No	Unlisted	.65
2224	**35-LA-218**	Flanagan	Upper Willamette	Toepel and Minor	1980	6-36	Excavation	1/4"	Unlisted	Yes	Yes	No	No	Yes	No	22	20.6
8214	**35-LA-264**	GWEN	Upper Willamette	Baxter and Minor	1987	15-19	Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	16	Unable to Determine
218	**35-LA-265**	-	Coast Fork	Cole	1978	6-19	Shovel Test	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
10521	**35-LA-265**	Shortridge Park	Coast Fork	Bland	1989	19-41	Shovel Probe and Excavation	1/8"	Unlisted	No	No	No	No	No	No	8.25	4.125

19996	**35-LA-285**	Harrington	Middle Fork	Winkler	2005	11-15	Excavation	1/8"	Unlisted	No	No	No	No	No	Yes	5	Unable to Determine
11382	**35-LA-295**	Gate Creek #1	Middle Fork	Flenniken, Ozbun, and Markos	1990	26, 31-78	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	10.25	8.45
2226	**35-LA-31**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excavation	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
2226	**35-LA-32**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excavation	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
10064	**35-LA-320**	-	Middle Fork	Flenniken et al.	1989	22-24, 32-50	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	11	Unlisted
9868	**35-LA-325**	-	McKenzie	Bergland	1989a	1-3	Test Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	1.5	.75
15329	**35-LA-328**	-	McKenzie	Oetting	1994	13-37	Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	2.75	1.7
2226 15329	**35-LA-33**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excavation	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
	35-LA-330	-	McKenzie	Oetting	1994	13, 38-56	Excavation Units and Shovel Test Probes	1/8"	Unlisted	No	No	No	No	No	No	3.75	1.825

2226	**35-LA-34**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excava tion	Unliste d	Unlisted	No	No	No	No	No	No	Unlist ed	Unlist ed
2226	**35-LA-35**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excava tion	Unliste d	Unlisted	No	No	No	No	No	No	Unlist ed	Unlist ed
8471	**35-LA-354**	-	Mid-Willa mette	Baxter and Minor	1987	8, 2132	Shovel Probe (square), Excava tion	1/8"	Unlisted	No	No	No	No	No	No	5.75	3.24
2226	**35-LA-36**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excava tion	Unliste d	Unlisted	No	No	No	No	No	No	Unlist ed	Unlist ed
7513	**35-LA-363**	Mill Creek No. 6	McKe nzie	Southard	1986	3-6	Square Shovel Probe and Test Excava tion Unit	1/4"	Unlisted	No	No	No	No	No	No	79	8.35
2226	**35-LA-37**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excava tion	Unliste d	Unlisted	No	No	No	No	No	No	Unlist ed	Unlist ed
2226	**35-LA-38**	-	Middle Fork	Cole	1988		Shovel Test Pits and Excava tion	Unliste d	Unlisted	No	No	No	No	No	No	Unlist ed	Unlist ed
3556	**35-LA-39**	-	Middle Fork	Baxter	1982	3-20	Excava tion	1/4" and 1/8"	Unlisted	No	Yes	No	Yes	No	No	Unlist ed	Unlist ed

7292	**35-LA-390**	Cupola	McKenzie	Jenkins	1986	4-16	Excavation	1/4"	Unlisted	No	Yes	No	No	No	No	8	4
867	**35-LA-41**	-	Upper Willamette	Miller	1975	311-347	Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
867	**35-LA-42**	-	Upper Willamette	Miller	1975	311-347	Excavation	1/4"	Unlisted	No	No	No	Yes	Yes	No	6	4.8
17320	**35-LA-420**	-	Upper Willamette	O'Neill and Connolly	1999	165-239	Excavation Unit	1/8"	Unlisted	No	No	No	No	Yes	No	36	45.1
4758	**35-LA-426**	-	Middle Fork	Heid	1983c	1-4	Excavation	1/4"	Unlisted	No	No	No	No	No	No	3	Unable to Determine
4769	**35-LA-434**	Norway	McKenzie	Bell	1982	6-16	Test Probes and Test Pits	Unlisted	Unlisted	No	No	No	No	No	No	4.44	Unable to Determine
8382	**35-LA-439**	Long Tom	Upper Willamette	O'Neill	1987	25-77	Auger, Excavation	1/4"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
8382	**35-LA-440**	-	Upper Willamette	O'Neill	1987	78-92	Auger, Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
10064	**35-LA-444**	-	Middle Fork	Flenniken et al.	1989	22-24, 50-68	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	13	Unlisted
11128	**35-LA-458**	Pat Saddle	McKenzie	Bergland	1990a	1-3	Test Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	3.75	1.875
8400	**35-LA-469**	Hatchery Tributary	McKenzie	Southard	1987	4-21	Shovel Test Units	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	6	1.7125
8407	**35-LA-475**	-	Middle Fork	Heid	1987	5-14	Shovel Probes	1/4"	Unlisted	No	No	No	No	No	No	23	Unable to Deter

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22355	**35-LA-475**	Packard Creek Campground	Middle Fork	Gauthier	2007	7-12	Excavation	1/8"	Unlisted	No	No	No	No	No	No	4	3.1
7296	**35-LA-519**	Bills Creek	Middle Fork	Heid	1986	10-21	Test Units	1/4"	Unlisted	No	No	No	No	No	No	3.25	Unlisted
3791	**35-LA-564**	-	Middle Fork	Heid	1982	1-4	Excavation Units	Unlisted	Unlisted	No	No	No	No	No	No	.45	.18
12588	**35-LA-57**	-	Middle Fork	Silvermoon	1991	4.1, 5.25-5.35	Square Shovel Probe and Test Excavation Unit	1/4"	Unlisted	No	No	No	No	No	No	3.5	1.821
6177	**35-LA-584**	Dingo Boots	Middle Fork	Heid	1984	7-22	Test Units	1/4"	Unlisted	No	No	No	No	No	No	3.25	Unlisted
4988	**35-LA-600**	Salix	Middle Fork	Heid	1983a	7-15	Test Units	1/4"	Unlisted	No	No	No	No	No	No	5.16	1.548
5435	**35-LA-623**	-	Middle Fork	Held	1983b	6-12	Test Units	1/4"	Unlisted	No	No	No	No	No	No	3.2	Unlisted
10064	**35-LA-632**	-	Middle Fork	Flenniken et al.	1989	22-24, 99-107	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	7	Unlisted
10064	**35-LA-633**	-	Middle Fork	Flenniken et al.	1989	22-24, 85-99	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	7	Unlisted
12588																	
	35-LA-64	Stultz	Coast Fork	Silvermoon	1991	4.1-5.36	Square Shovel Probe and Test Excavation Unit	1/4"	Unlisted	No	No	No	No	No	No	6	3

10533	**35-LA-656**	Deadhorse	Middle Fork	Churchill	1989	19, 49-64	Excavation	1/8"	Count	Yes	Yes	No	Yes	Yes	No	Unlisted	1.7
15338	**35-LA-657**	-	McKenzie	Oetting	1995	1-11	Shovel Test Probes	1/8"	Unlisted	No	No	No	No	No	No	4	1.7
8382	**35-LA-658**	-	Upper Willamette	O'Neill	1987	107-119	Auger, Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
16758	**35-LA-71**	-	Mid-Willamette	Fagan et al.	1998	4, 48	Shovel Test	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
7135	**35-LA-727**	Colt	Middle Fork	Cox	1985	5-12	Shovel Probes and Shovel Tests	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unlisted
11119	**35-LA-733**	-	Coast Fork	Bland and Toepel	1988	1-9	Shovel Probe and Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	3
7306	**35-LA-741**	-	McKenzie	Cox	1986	7-12	Square Test Probes	1/4"	Unlisted	No	No	No	No	No	No	3.25	Unlisted
7973	**35-LA-754**	-	Upper Willamette	Toepel and Baxter	1987	12-19	Shovel Probe, Excavation	1/8"	Unlisted	No	No	No	No	No	No	3	2.3
7700	**35-LA-755**	-	Upper Willamette	Baxter and Topel	1986	2-7	Auger, Shovel Probe, Excavation	1/8"	Unlisted	No	No	No	No	No	No	2	1.2
7700	**35-LA-756**	-	Upper Willamette	Baxter and Topel	1986	2-7	Auger, Shovel Probe, Excavation	1/8"	Unlisted	No	No	No	No	No	No	2	1.4

8382	**35-LA-758**	-	Upper Willamette	O'Neill	1987	93-106	Auger, Excavation	1/4"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
8382	**35-LA-760**	-	Upper Willamette	O'Neill	1987	120-131	Auger, Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
10235	**35-LA-802**	Katz Rockshelter	Middle Fork	Churchill and Jenkins	1989	17, 47-57	Excavation	1/8"	Count	Yes	Yes	No	Yes	No	No	Unlisted	1.25
9448	**35-LA-807**	Diamond Lil	Middle Fork	Winkler	1988	7-18	Shovel Probes and Test Units	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	12	6
10064	**35-LA-814**	-	Middle Fork	Flenniken et al.	1989	22-24, 69-84	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	7	Unlisted
10063	**35-LA-818**	Manson	Middle Fork	Southard	1989	4-14	Test Pits	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unlisted
10055	**35-LA-822**	Warehouse	McKenzie	Flenniken et al.	1989	19-23, 25-31, 71	Test Probe and Test Unit	1/8"	Unlisted	No	No	No	No	No	No	5	2.5
11373	**35-LA-822**	-	McKenzie	Bergland	1990b	1-4	Test Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	1.25	.625
11119	**35-LA-836**	-	Coast Fork	Bland and Toepel	1988	1-9	Shovel Probe and Excavation	1/8"	Unlisted	No	No	No	No	No	No	6.25	2.2
9881	**35-LA-846**	-	McKenzie	Bergland	1989b	1-2	Test Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	1.25	.625
10540	**35-LA-848**	Crack Shot	McKenzie	Southard	1989	3-13	Test Pit	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted

10541	**35-LA-857**	-	McKenzie	Winthrop and Gray	1989	6-23	Test Probes and Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	8	5.75
11125	**35-LA-875**	Vacuum	McKenzie	Southard	1990	4-23	Test Pit and Excavation Unit	1/4"	Unlisted	No	No	No	No	No	No	28	Unable to Determine
8471	**35-LA-88**	-	Upper Willamette	Baxter and Minor	1987	8, 14-16	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	2	1
8471	**35-LA-89**	-	Upper Willamette	Baxter and Minor	1987	8, 16-18	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	1	.5
11893	**35-LA-91**	Fritz	McKenzie	Bergland	1990c	1-3	Test Excavation Units	1/4"	Unlisted	No	No	No	No	No	No	1.5	.75
16389	**35-LA-917**	-	Middle Fork	Steffen and Winkler	1998	3, 8-9	Shovel Test Units (50 x 50)	1/8"	Unlisted	No	No	No	No	No	No	2	Unlisted
12322, 12570	**35-LA-927**	-	Coast Fork	Oetting	1991	1-10	Excavation	1/8"	Unlisted	No	No	No	No	No	No	15	4.1
11626	**35-LA-928**	-	Middle Fork	Cox	1990	1-12	Test Probes	1/4"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
11882	**35-LA-945**	Scant	McKenzie	Southard	1991	5-13	Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	7	.8
12745	**35-LA-951**	-	McKenzie	Toepel and Bland	1991	5-17	Test Probe and Test Pit	Unlisted	Unlisted	No	Yes	No	No	No	No	6.25	2.2
12319	**35-LA-957**	-	Coast Fork	Stevens and Galm	1991	1-5	Shovel Test	1/4"	Unlisted	No	No	No	No	No	No	0.625	.125
15743	**35-LA-958**	Rum	McKenzie	Southard	1996	5-8	Excavation Units	1/8"	Unlisted	No	No	No	No	No	No	3	.4

12588	**35-LA-969**	Williamson	Coast Fork	Silvermoon	1991	4.1-5.36	Square Shovel Probe and Test Excavation Unit	1/4"	Unlisted	No	No	No	No	No	No	2.75	1.375
13032	**35-LA-978**	-	Mid-Willamette	Fagan et al.	1992	48, 338-346	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	5	6.5
17898	**35-LA-987**	-	McKenzie	South and Bergland	1997	1-3	Test Pits (50x50)	1/8"	Unlisted	No	No	No	No	No	No	1.75	0.575
12960	**35-LA-995**	Winberry Saddle	Middle Fork	Winkler	1992	11-17	Test Probes	1/8"	Unlisted	No	No	No	No	No	No	4.25	2.725
21066	**35-LIN-1116**	-	McKenzie	Oetting	2006	15-18, 44	Shovel probes (round and square)	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	1.2
6710	**35-LIN-118**	Yukwah	S. Santiam	Lindberg-Muir	1964	5-8	Excavation	1/4"	Unlisted	No	No	No	No	No	No	7.75	4.85
7317	**35-LIN-133**	-	N. Santiam	Elsesser	1985	8-11	Excavation	1/4"	Unlisted	No	No	No	No	No	No	5.25	2.625
7144	**35-LIN-139**	-	S. Santiam	Winthrop and Gray	1985	10-18	Excavation and Test Pits (50x50)	1/4"	Unlisted	No	No	No	No	No	No	8	Unlisted
8009	**35-LIN-186**	North Park Salvage	N. Santiam	Jenkins and Churchill	1987	iii-viii, 12-13	Excavation	1/4"	Unlisted	No	No	No	No	No	No	8	6.9
18691	**35-LIN-187**	-	N. Santiam	Helzer	2003	17-30	Test Pit, Excavation, Auger	1/8"	Unlisted	No	No	No	No	No	No	1.34	.04
18691	**35-LIN-188**	-	N. Santiam	Helzer	2003	17-30	Test Pit, Excavation,	1/8"	Unlisted	No	No	No	No	No	No	.25	.1

							Auger									
12371	**35-LIN-22**	Kropf	Upper Willamette	Davis	1970	9-32	Unlisted	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
5449	**35-LIN-230**	Soda Fork Way II	S. Santiam	Lindberg-Muir	1983b	3-6	Excavation	1/4"	Unlisted	No	No	No	No	No	No	2.34	0.91
5448	**35-LIN-231**	Soda Fork Way I	S. Santiam	Lindberg-Muir	1983a	3-6	Excavation	1/4"	Unlisted	No	No	No	No	No	No	.63	0.2331
4578	**35-LIN-241**	-	N. Santiam	Bell	1982	4-12	Test Probes, Test Pits	Unlisted	Unlisted	No	No	No	No	No	No	2	1.2
8009	**35-LIN-253**	North Park Headwaters	N. Santiam	Jenkins and Churchill	1987	iii-viii, 12	Excavation	1/4"	Unlisted	No	No	No	No	No	No	11.5	3.3
7539	**35-LIN-292**	-	Upper Willamette	Lebow	1986	15-25	Excavation	1/4"	Unlisted	No	No	No	No	No	No	5	Unable to Determine
7542	**35-LIN-301**	Dopey	S. Santiam	Elsesser	1985	6-13	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	8	Unlisted
9899	**35-LIN-301**	Bear Saddle	S. Santiam	Nilsson	1989	23, 26	Excavation	1/8"	Unlisted	No	No	No	No	No	No	20	Unlisted
9900	**35-LIN-302**	-	N. Santiam	Spencer	1989	12-47	Shovel Test and Excavation	1/8"	Unlisted	No	No	No	No	No	No	8	Unlisted
8004	**35-LIN-310**	Moose Ridge #4	S. Santiam	Cox	1987	7-8	Excavation	1/4"	Unlisted	No	No	No	No	No	No	1	.4
8005	**35-LIN-311**	Moose Ridge #3	S. Santiam	Prouty and Cox	1987	5-6	Excavation	1/4"	Unlisted	No	No	No	No	No	No	5	3.5
8251	**35-LIN-312**	Three Chimney Peak One	S. Santiam	Lindberg-Muir	1986	5-10	Excavation	1/4"	Unlisted	No	No	No	No	No	No	4.5	1.755
9904	**35-LIN-312**	Chimney Peak One	S. Santiam	Jenkins and Churchill	1988	11-22	Excavation	1/8"	Unlisted	No	No	No	No	No	No	20	Unlisted

8251	**35-LIN-313**	Three Chimney Peak	S. Santiam	Lindberg-Muir	1986	5-10	Excavation	1/4"	Unlisted	No	No	No	No	No	No	2.5	Unable to Determine
8250	**35-LIN-320**	Two Dane Saddle	McKenzie	Cole	1986	5-11	Test Units	1/4"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
8970	**35-LIN-328**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	1	.5
8970	**35-LIN-334**	-	S. Santiam	Cole	1987	5-18	Square test units	1/4"	Unlisted	No	No	No	No	No	No	1.5	.96
10081	**35-LIN-363**	Sheep Joe I	S. Santiam	Winthrop and Gray	1988	10-15	Shovel Probe (square)	1/4"	Unlisted	No	Yes	No	No	No	No	18.5	Unlisted
11395	**35-LIN-373**	Swamp Peak Trail	S. Santiam	Flenniken, Ozbun, and Markos	1990	17, 24	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	5	Unable to Determine
12607	**35-LIN-391**	-	S. Santiam	Flenniken, Ozbun, and Markos	1991	19, 29-47	Square test units and Excavation	1/8"	Unlisted	No	Yes	No	No	No	No	9	Unlisted
12607	**35-LIN-392**	-	S. Santiam	Flenniken, Ozbun, and Markos	1991	19, 54-65	Square test units and Excavation	1/8"	Unlisted	No	No	No	No	No	No	9	Unlisted
12607	**35-LIN-393**	-	S. Santiam	Flenniken, Ozbun, and Markos	1991	19, 69-75	Square test units and Excavation	1/8"	Unlisted	No	No	No	No	No	No	9	Unlisted
12607	**35-LIN-400**	-	S. Santiam	Flenniken, Ozbun, and Markos	1991	19, 78-83	Square test units and Excavation	1/8"	Unlisted	No	No	No	No	No	No	9	Unlisted
17540	**35-LIN-416**	Cassnor #3	Upper Willamette	Southard, Michael D.	2000	5-11	1 meter test pits	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	41	4.8

20499	**35-LIN-428**	-	Upper Willamette	Henrickson and Winterhoff	2005	14-19	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	1.25	.65
13032	**35-LIN-429**	-	Mid-Willamette	Fagan et al.	1992	48, 255-256	Shovel test, Auger	Unlisted	Unlisted	No	No	No	No	No	No	.75	.32
13032	**35-LIN-435**	-	Mid-Willamette	Fagan et al.	1992	48, 283-284	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	1	1
13032	**35-LIN-437**	-	Mid-Willamette	Fagan et al.	1992	48, 298-313	Shovel test, Auger	Unlisted	Unlisted	No	No	No	No	No	No	1	.75
13032	**35-LIN-442**	-	Mid-Willamette	Fagan et al.	1992	48, 298-313	Excavation, Shovel Test, Auger	Unlisted	Unlisted	No	No	No	No	No	No	3	1.71
13032	**35-LIN-443**	-	Mid-Willamette	Fagan et al.	1992	48, 279-280	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	2	1
13032	**35-LIN-451**	-	Mid-Willamette	Fagan et al.	1992	48, 316-330	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	4	4.25
13032	**35-LIN-457**	-	S. Santiam	Fagan et al.	1992, 1996	48, 202-214	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	2	Unable to Determine
13032	**35-LIN-458**	-	S. Santiam	Fagan et al.	1992	48, 201-202	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	1	1
13032	**35-LIN-459**	-	Mid-Willamette	Fagan et al.	1992, 1996	48, 215-231	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	2	.9
13032	**35-LIN-460/461**	-	Mid-Willamette	Fagan et al.	1992	48, 214-215	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	.25	Unable to Determine

13032	**35-LIN-468**	-	Mid-Willamette	Fagan et al.	1992	48, 257-276	Excavation, Auger	1/4" and 1/8"	NISP, MNI, Weight	Yes	Yes	No	No	No	No	4	3.63
13032	**35-LIN-470**	-	Mid-Willamette	Fagan et al.	1992	48, 286-296	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	2	1.04
15208	**35-LIN-503**	-	S. Santiam	Flenniken and Ozbun	1994	20, 68	Excavation Test Unit	1/8"	Unlisted	No	No	No	No	No	No	6	7.4
15100	**35-LIN-525**	-	N. Santiam	Draper et. Al.	1994	40, 68-104	Excavation	1/8"	Unlisted	No	No	No	No	No	No	7	5.95
13611	**35-LIN-554**	-	Upper Willamette	Regan and Thomas	1993	5	Shovel Tests, Excavation	Unlisted	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
14450	**35-LIN-572**	-	S. Santiam	Linderman	1992	1-3	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	3.5	1.575
14459	**35-LIN-606**	-	S. Santiam	Linderman	1992	1-4	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	3.5	1.175
15744	**35-LIN-624**	-	Upper Willamette	Lebow et al.	1996	3.1-3.10, 6.1-6.2	Shovel Probe, Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	1.88
15744	**35-LIN-625**	-	Upper Willamette	Lebow et al.	1996	3.1-3.10, 7.1	Shovel Probe, Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	4.61
15744	**35-LIN-626**	-	Upper Willamette	Lebow et al.	1996	3.1-3.10, 8.2-8.24	Shovel Probe, Excavation	1/4"	Unlisted	No	No	No	Yes	No	No	Unable to Determine	6.35
15744	**35-LIN-628**	-	Upper Willamette	Lebow et al.	1996	3.1-3.10, 9.2-9.19	Shovel Probe, Excavation	1/4"	Unlisted	No	No	No	Yes	Yes	No	Unable to Determine	7.82

20619	**35-LIN-650**	-	S. Santiam	Baxter and Connolly	2006	6-11	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	3.75	4.35
20619	**35-LIN-650**	-	Upper Willamette	Baxter and Connolly	2006	7-11	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	3.75	4.35
16402	**35-LIN-651**	-	S. Santiam	Southard	ND	4-17	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	2.5	1.79
16908	**35-LIN-651**	-	S. Santiam	Southard	1999	1-12	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	1.75	1.05
260	**35-LIN-659**	-	Upper Willamette	Southard	1977	1-7	Excavation	1/4"	Unlisted	No	Yes	No	No	No	No	1	.4
17786	**35-LIN-660**	Spicer Drive	S. Santiam	O'Neill and Jenkins	2001	13-22	Excavation	1/8"	Unlisted	No	Yes	No	No	No	No	13.75	6.6
18691	**35-LIN-673**	-	N. Santiam	Helzer	2003	40-44	Test Pit, Excavation, Auger	1/8"	Unlisted	No	No	No	No	Obsidian Hydration	No	.25	.1
18691	**35-LIN-674**	-	N. Santiam	Helzer	2003	40-44	Test Pit, Excavation, Auger	1/8"	Unlisted	No	No	No	No	Obsidian Hydration	No	.25	Unable to Determine
18691	**35-LIN-675**	-	N. Santiam	Helzer	2003	17-30	Test Pit, Excavation, Auger	1/8"	Unlisted	No	No	No	No	Obsidian Hydration	No	3.75	Unable to Determine
20499	**35-LIN-678**	-	Upper Willamette	Henrickson and Winterhoff	2005	8-10\	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	4.75	2.67
20499	**35-LIN-679**	-	Upper Willamette	Henrickson and Winterhoff	2005	12-14	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	.5	.25
19494	**35-LIN-682**	-	Upper Willamette	Robert R. Munsil	2005	14-27	Shove Test Probes and Shovel Test	1/8"	Unlisted	No	No	No	No	No	No	5.25	2.4

							Pits										
19494	**35-LIN-683**	-	Upper Willamette	Robert R. Munsil	2005	14-27	Shove Test Probes and Shovel Test Pits	1/8"	Unlisted	No	Yes	No	Yes	Yes	No	3.75	3
20044	**35-LIN-692**	-	S. Santiam	Wilson	1998	9-19	Shovel Probe (square), Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	8.5	Unable to Determine
21066	**35-LIN-695**	-	McKenzie	Oetting	2006	15-18, 36	Shovel probes (round and square)	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	1.1
21070	**35-LIN-698**	-	McKenzie	Oetting	2006	15-18, 37	Shovel probes (round and square)	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	3.3
20586	**35-LIN-702**	-	S. Santiam	Becker	2006	16-27	Shovel Test Pit (Round)	1/4"	Unlisted	No	No	No	No	No	No	7.1	Unable to Determine
20947	**35-LIN-702**	-	S. Santiam	Laybolt et al.	2006	11-14	Quarter test units and excavation units	1/8"	Unlisted	No	No	No	No	No	No	3	1.65
22219	**35-LIN-712**	-	Upper Willamette	Ruiz et al	2008	6-17	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	2.25	1.5
22219	**35-LIN-743**	-	Upper Willamette	Ruiz et al	2008	6-17	Square Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	1.25	.8
13032	**35-MA-105**	-	N. Santiam	Fagan et al.	1992	48, 180-188	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	Yes	No	2	.9

15608	**35-MA-105**	-	N. Santiam	Fagan et al.	1996	4.1-4.47	Excavation	1/4" and 1/8"	Unlisted	No	No	No	Yes	No	No	23	Unlisted
13032	**35-MA-107**	-	Mid-Willamette	Fagan et al.	1992	48, 169-178	Excavation, Shovel Test, Auger	Unlisted	Unlisted	No	No	No	No	Yes	No	2.75	1.41
15608	**35-MA-107**	-	N. Santiam	Fagan et al.	1996	3.1-3.38	Excavation	1/4" and 1/8"	Unlisted	No	Yes	No	Yes	No	No	24	Unlisted
7554	**35-MA-11**		Mid-Willamette	Minor and Beckham	1986	29-34	Auger, Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	1	.5
19307	**35-MA-11**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 17-23	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
18705	**35-MA-11**	-	Mid-Willamette	Tasa	2003	5	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
13032	**35-MA-110**	-	N. Santiam	Fagan et al.	1992	48, 191-195	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	1	1.5
13032	**35-MA-111**	-	N. Santiam	Fagan et al.	1992	48, 191-195	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	No	No	.5	.25
13032	**35-MA-114**	-	N. Santiam	Fagan et al.	1992	48, 161-168	Excavation, Auger	Unlisted	Unlisted	No	No	No	No	Yes	No	2	1

15608	**35-MA-114**	-	N. Santiam	Fagan et al.	1996	2.1-2.61	Excavation	1/4" and 1/8"	Unlisted	No	Yes	No	Yes	Yes	No	42	Unlisted
7554	**35-MA-12**	-	Mid-Willamette	Minor and Beckham	1986	29-34	Auger, Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
19307	**35-MA-12**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 23-27	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
19012	**35-MA-142**	-	Mid-Willamette	Darby	2004	14-16, 18-21	Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	.96	.288
14618	**35-MA-142**	-	Mid-Willamette	Ellis	1994	17-33	Trench Sampling, Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
14618	**35-MA-143**	-	Mid-Willamette	Ellis	1994	17-33	Trench Sampling, Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
14618	**35-MA-144**	-	Mid-Willamette	Ellis	1994	17-33	Trench Sampling, Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
2624	**35-MA-16**	-	Mid-Willamette	Thoms and Carlevato	1981	35-39	Test pit, auger, shovel test	1/4" and unscreened	Unlisted	No	No	No	Yes	No	No	Unlisted	Unlisted
18487	**35-MA-176**	-	Mid-Willamette	Baker, Ellis, and Fagan	2003	1-2	Excavation	1/8"	Unlisted	No	No	No	No	No	No	6.75	Unlisted

19117	**35-MA-183**	-	Mid-Willamette	Fagan, Baker, and Chapman	2004	2-3, 4-5	Shovel test, quarter test units, and test units	1/4" and 1/8"	Unlisted	No	Yes	No	No	No	No	3.94	Unable to determine
19692	**35-MA-183**	-	Mid-Willamette	Smits et. Al.	2004	4-15	Excavation units and quarter test units	1/4" and 1/8"	NISP	No	Yes	No	No	No	No	4.5	2.25
19819	**35-MA-196**	-	Mid-Willamette	Munsil	2005	2-4	Test Probes	1/8"	Unlisted	No	No	No	No	No	No	6	3
20431	**35-MA-197**	-	Mid-Willamette	Munsil	2006		Shovel Probe (round and square)	1/8"	Unlisted	No	No	No	No	No	No	3.93	Unlisted
19985	**35-MA-217**	-	N. Santiam	Kelly	2005	2-9	Test Pit (50x50)	1/8"	Unlisted	No	No	No	No	No	No	1.5	.675
12626	**35-MA-22**	-	N. Santiam	Churchill and Jenkins	1991	19-42	Shovel Probes and Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	11	Unlisted
20296	**35-MA-222**	-	Mid-Willamette	Tasa and Knowles	2005	3-5	Shovel tests	1/8"	Unlisted	No	Yes	No	No	No	No	Unlisted	.297
5659	**35-MA-48**	-	N. Santiam	Jenkins and Churchill	1984	5-8	Excavation	1/4"	Unlisted	No	No	No	No	No	No	6	Unable to determine
11663 4011	**35-MA-49**	-	N. Santiam	Beardsley	1990	8-26	Trench and Excavation	1/8" and 1/16"	Unlisted	No	No	No	No	No	No	21.5	5.4
	35-MA-51	-	N. Santiam	Regula	1982	3-5	Shovel Test	Unlisted	Unlisted	No	No	No	No	No	No	6	Unable to determine

17691	**35-MA-57**	-	Mid-Willamette	Bell	No Date	1-7	Shovel Probe, Excavation	1/4" and 1/8"	Unlisted	No	No	No	No	No	Yes	Unlisted	Unlisted
7554	**35-MA-63**	-	Mid-Willamette	Minor and Beckham	1986	29-34	Auger, Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	.25	.125
19307	**35-MA-63**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 27-29	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
7554	**35-MA-64**	-	Mid-Willamette	Minor and Beckham	1986	29-34	Auger, Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	.5	.25
19307	**35-MA-64**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 29-35	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
7554	**35-MA-64**	-	Mid-Willamette	Tasa	2003	1-4	Excavation	Unlisted	Unlisted	No	Yes	No	Yes	Yes	No	28	Unlisted
7554	**35-MA-65**	-	Mid-Willamette	Minor and Beckham	1986	29-34	Auger, Shovel Probe	1/8"	Unlisted	No	No	No	No	No	No	.5	.25
19307	**35-MA-65**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 35-39	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	Unable to Determine	Unable to Determine
18705	**35-MA-65**	-	Mid-Willamette	Tasa	2003	4-5	Excavation	Unlisted	Unlisted	No	Yes	No	Yes	No	No	96	Unlisted
20367	**35-MA-66**	-	N. Santiam	Kelly	2005	13-25	Test Pit, Excavation,	1/8"	Unlisted	No	No	No	No	No	No	6.5	3.35

							Auger										
19307	**35-MA-69**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 39	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
	35-MA-7	-	Mid-Willamette	Cole and Pettigrew	1976	7-11	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	1	1.2
19307	**35-MA-7**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 9-12	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
2392	**35-MA-7**		Mid-Willamette	Pettigrew	1980	7-16	Excavation	1/4"	Unlisted	No	No	No	Yes	No	No	36	21
19307	**35-MA-70**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 39-41	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
	35-MA-8	-	Mid-Willamette	Cole and Pettigrew	1976	7-11	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	3	Unable to determine
19307	**35-MA-8**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 13-15	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
	35-MA-9	-	Mid-Willamette	Cole and Pettigrew	1976	7-11	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	2	Unable to determine
19307	**35-MA-9**	-	Mid-Willamette	Minor and Toepel	1995	5-6, 1517	Shovel Probe (square), Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine

2392	**35-MA-9**	-	Mid-Willamette	Pettigrew	1980	16-19	Excavation	1/4"	Unlisted	No	No	No	No	No	No	72	19.28
11660	**35-MA-91**	-	N. Santiam	Silvermoon	1990	9-10	Auger	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to determine
11660	**35-MA-92**	-	N. Santiam	Silvermoon	1990	9-10	Auger	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to determine
11661	**35-MA-92**	-	N. Santiam	Silvermoon	1990	11-34	Excavation and shovel tests	1/4" and 1/8"	Number	Yes	Yes	No	Yes	No	No	8.5	4.875
12625	**35-MA-92**	-	N. Santiam	Tasa	1991	6-18	Excavation	1/8"	Unlisted	No	Yes	No	No	No	No	2	1.425
21118	**35-MA-92**	-	N. Santiam	Henrickson and Winterhoff	2006	9, 12-13	Excavation	1/8"	Unlisted	No	No	No	No	No	No	2.25	.9
13223	**35-MA-94**	-	Mid-Willamette	O'Neill	1992	12-20	Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unlisted	1.8
11933	**35-MA-94**	Ruef	Molalla	Keeler	1991	2-5	Shovel Probes and Excavation	1/4"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
13223	**35-MA-95**	-	Mid-Willamette	O'Neill	1992	30-36	Excavation	Not listed	Unlisted	No	No	No	No	No	No	Unlisted	2.1
13223	**35-MA-96**	-	Mid-Willamette	O'Neill	1992	37-43	Excavation	1/8"	Unlisted	No	No	No	No	No	No	5.25	.9
13223	**35-MA-97**	-	Mid-Willamette	O'Neill	1992	44-53	Excavation	1/8"	Unlisted	No	No	No	No	No	No	3.75	1.25
13223	**35-MA-98**	-	Mid-Willamette	O'Neill	1992	54-61	Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unlisted	1.4
15468	**35-PO-15**	-	Upper Willamette	Smith and Baxter	1996	25-30, 35-37	Test Pit (unsure of meanin	1/8"	Unlisted	No	No	No	No	Yes	No	12	6.7

g)

2624	**35-PO-2**	-	Mid-Willamette	Thoms and Carlevato	1981	16-26	Test pit, auger, shovel test	1/4" and unscreened	Unlisted	No	Yes	No	Yes	No	No	Unlisted	Unlisted
12805	**35-PO-21**	-	Mid-Willamette	Gilsen	1989	40-44	Excavation	1/4"	Unlisted	No	No	No	No	No	No	8	4.25
12805	**35-PO-22**	-	Mid-Willamette	Gilsen	1989	45-51	Excavation	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
2624	**35-PO-3**	-	Mid-Willamette	Thoms and Carlevato	1981	26-32	Test pit, auger, shovel test	1/4" and unscreened	Unlisted	No	Yes	No	Yes	No	No	Unlisted	Unlisted
12805	**35-PO-31**	-	Mid-Willamette	Gilsen	1989	44-45	Excavation	1/4"	Unlisted	No	Yes	No	No	No	No	4	1.75
2624	**35-PO-4**	-	Mid-Willamette	Thoms and Carlevato	1981	32-35	Test pit, auger, shovel test	1/4" and unscreened	Unlisted	No	No	No	Yes	No	No	Unlisted	Unlisted
15468	**35-PO-47**	-	Upper Willamette	Smith and Baxter	1996	25-30, 35-37	Test Pit (unsure of meaning)	1/8"	Unlisted	No	No	No	No	No	No	10	7
8263	**35-PO-57**	-	Mid-Willamette	Gilsen	1987		Excavation	Unlisted	Unlisted	No	Yes	No	No	No	No	2	.5
12805	**35-PO-57**	-	Mid-Willamette	Gilsen	1989	51-55	Excavation	1/4"	Unlisted	No	Yes	No	No	No	No	2	Unlisted
17217	**35-PO-65**	-	Mid-Willamette	Tasa	1999	1-2	Shovel Probe, Excavation	1/8"	Unlisted	No	Yes	No	No	No	No	Unable to Determine	Unable to Determine
	35-PO-65	-	Mid-Willamette	Tasa and Connolly	2000	10-11	Shovel Probe	1/8"	Unlisted	No	Yes	No	No	No	No	10.75	5.7

19189	**35-PO-74**	-	Yamhill	O'Rourke and Kaehler	2004	13-20	Excavation	1/8"	Unlisted	No	No	No	No	Yes	No	2	.8
21374	**35-PO-78**	-	Yamhill	Wilt and Roulette	2007	13, 18-23	Quarter test units and shovel tests	1/4" and 1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	2.5
5670	**35-PO-8**	Gordon	Upper Willamette	Bell	1984	5-13	Test Pits, Test Holes	1/4"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
21977	**35-PO-83**	-	Mid-Willamette	Wilt and Roulette	2008	14, 19	Shovel Test	3 mm	Unlisted	No	No	No	No	No	No	.02	.032
21908	**35-PO-83**	-	Mid-Willamette	McCormick and Roulette	2008	18, 30	Quarter test units and excavation units	1/8"	Unlisted	No	Yes	No	No	No	No	2	1.33
21503	**35-PO-83**	-	Mid-Willamette	Roulette et. Al.	2007	15, 21, 29	Shovel test pits and quarter test units	1/8"	Unlisted	No	Yes	No	No	No	No	Unlisted	1.7
21422	**35-PO-83**	-	Mid-Willamette	Wilt	2007	2-4	Shovel test pits and quarter test units	1/8"	Unlisted	No	No	No	No	No	No	2.25	Unable to Determine
21910	**35-PO-84**	-	Yamhill	Becker and Roulette	2006	14-21	Shovel Test	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to determine
21910	**35-PO-85**	-	Yamhill	Becker and Roulette	2006	14-21	Shovel Test	1/4"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to determine
21850	**35-PO-86**	-	Mid-Willamette	McCormick	2008	11-16	Shovel tests	1/4"	Unlisted	No	No	No	No	No	No	.36	Unlisted

21908	**35-PO-87**	-	Mid-Willamette	McCormick and Roulette	2008	18, 41-42	Quarter test units and excavation units	1/8"	Unlisted	Yes	Yes	No	No	No	No	3	3.04
15377	**35-WN-17**	-	Tualatin	Munsil	1995	6-14	Test Probes and Test Pits	1/8"	Unlisted	No	No	No	No	No	No	13.25	7.3
11952	**35-WN-19**	-	Tualatin	Ellis and Fagan	1990	14-27	Excavation and Auger	1/8"	Unlisted	No	No	No	No	No	No	2	1.3
6394	**35-WN-20**	-	Tualatin	Simmons	1985	4-12	Shovel Test Pit and Auger	1/8"	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
2596	**35-WN-4**	-	Tualatin	Davis	1970	7-14	Shovel Test Pit	Unlisted	Unlisted	No	Yes	No	No	No	No	Unlisted	Unlisted
16435	**35-WN-45**	-	Tualatin	Ellis and Forgeng	1998	24-36	Excavation	1/8"	Unlisted	No	No	No	Yes	No	No	3.25	1.4
8078 8078	**35-YA-10**	-	Yamhill	Stewart	No Date	III2-III5	Excavation	1/4" with small percentage screend through 1/8" mesh		No	No	No	No	No	No	Unable to Determine	Unable to determine
	35-YA-12	-	Yamhill	Stewart	No Date	III6-III8	Excavation	1/4" with small percentage screend through 1/8" mesh		No	No	No	No	No	No	Unable to Determine	Unable to determine

21977	**679-1**	-	Mid-Willamette	Wilt and Roulette	2008	14, 20, 25-28	Shovel Test	3 mm	Unlisted	No	Yes	No	No	No	No	.013	.02
21977	**679-2**	-	Mid-Willamette	Wilt and Roulette	2008	14, 20, 28-29	Shovel Test	3 mm	Unlisted	No	No	No	No	No	No	.025	.05
21977	**679-3**	-	Mid-Willamette	Roulette and Wilt	2008	14, 20, 29-34	Shovel Test	3 mm	Unlisted	No	Yes	No	No	No	No	.01	.02
21971	**AAR 702-1**	-	Yamhill	Becker et. Al.	2008	14, 24-41	Shovel Test	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
21971	**AAR 702-2**	-	Yamhill	Becker et. Al.	2008	14, 24-41	Shovel Test	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
21971	**AAR 702-3**	-	Yamhill	Becker et. Al.	2008	14, 24-41	Shovel Test	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
11943	**JS-1**	-	Mid-Willamette	O'Neill	1990	1-3	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
13223	**JS-2**	-	Mid-Willamette	O'Neill	1992	21-25	Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unlisted	1
11943	**JS-2**	-	Mid-Willamette	O'Neill	1990	1, 3-4	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	1.5	1.2
13223	**JS-3**	-	Mid-Willamette	O'Neill	1992	26-29	Excavation	1/8"	Unlisted	No	No	No	No	No	No	Unlisted	.65
11943	**JS-3**	-	Mid-Willamette	O'Neill	1990	1, 4	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	.75	.375
11943	**JS-4**	-	Mid-Willamette	O'Neill	1990	1,4	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	2	1.2
11943	**JS-5**	-	Mid-Willamette	O'Neill	1990	1, 5	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	5.25	3.15

11943	**JS-6**	-	Mid-Willamette	O'Neill	1990	1, 6-8	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
11943	**JS-7**	-	Mid-Willamette	O'Neill	1990	1, 8	Shovel Probe (square)	1/8"	Unlisted	No	No	No	No	No	No	2.75	.63
21757	**Unnamed**	-	Mid-Willamette	Becker and Roulette	2008	13	Shovel Tests	1/8"	Unlisted	No	No	No	No	No	No	.66	Unlisted
22068	**Unnamed**	AAR745-1	Mid-Willamette	Roulette and Lehman	2008	15-23	Shovel tests	1/4"	Unlisted	No	No	No	No	No	No	1	Unlisted
13617	-	Jory Cemetary	Mid-Willamette	Armitage	1993	10-12	Shovel Probe	Unlisted	Unlisted	No	No	No	No	No	No	Unable to Determine	Unable to Determine
16766	-	Lockmasters Office	Mid-Willamette	Minor, Musil, and Sprague	1992	7, 32	Excavation	1/8"	Unlisted	No	No	No	No	No	Yes	Unable to Determine	Unable to Determine
8077	-	Evans Site 1	Yamhill	Stewart	No Date	A13-A34	Excavation and shovel tests	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
8077	-	Evans Site 2	Yamhill	Stewart	No Date	A13-A34	Excavation and shovel tests	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
8077	-	Evans Site 3	Yamhill	Stewart	No Date	A13-A34	Excavation and shovel tests	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
8077	-	Evans Site 4	Yamhill	Stewart	No Date	A13-A34	Excavation and shovel tests	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted
8077	-	Wilkes Site 7	Yamhill	Stewart	No Date	A13-A34	Excavation and shovel tests	Unlisted	Unlisted	No	No	No	No	No	No	Unlisted	Unlisted

Appendix B. Summary Table of Resource Return Rates in the Willamette Valley

Name	Common Name	Reference	Habitat	Location of Modeled Data	Harvest Season	Post-Processing Yeild	Mean Value	Comment
Corylus spp	Hazelnut	Pojar and Mackinnon 1994, Reidhead 1980, USDA 2009	moist but well drained soils at low to middle elevations. Open forests, shady openings, thickets, claerings, rocky slopes and well drianed streamside habitats (Pojar and Mackinnon 1994)	Unknown	Picked in Early Autumn	492	492	Calculated based on Reidhead (1980) and USDA data. 1277 cal per 100 kg
Quercus spp.	Oak	Lindstrom 1996	Dry rocky soils to deep, rich , well drained soils, low elevations (Pojar and Mackinnon 1994)	Great Basin	Late Summer to Fall	2075	2075	
Camassia quamash	Camas	Thoms 1989, Pojar and Mackinnon 1994	Grassy Slopes and Meadows, low to middle elevation (P and M 1994)	Willamette, Spokane, Calispell Valley	July to September	2042	2042	Thoms also calculated Post-processing (After energy expended) yield = 2042 calories
Anas spp.	Ducks	Lindstrom 1996	Aquatic and semi-aquatic	Great Basin	unlisted, assuming year round	1975-2709	2342	
Sagittaria latifolia	Wapato	Darby 1996	Aquatic and semi-aquatic	Portland Basin	October to March	3240	3240	
Spermophilus spp.	Ground Squirrel	Simms 1985	Various	Great Basin	Hibernate and estivate for nearly half the year (available in early spring to late summer)	5390-6341	5865.5	
Oncorhynchus tshawytscha	Salmon	Plew 1983, Lindstrom 1996	Aquatic	Snake River, Truckee River	Early april to october (Martin	8034-9133	8583.5	Above Willamette

					2006)			Falls, Chinook Dried
Lepus spp	Cottontail Rabbit	Simms 1985	Various	Great Basin	Unlisted, assuming year round	8983-9800	9391.5	Calculation based on Lepus sylvaticus
Geomyidae	Gophers	Simms 1985	Various	Great Basin	unlisted, assuming year round	8983-10780	9881.5	
Oncorhynchus tshawytscha	Salmon		Aquatic	Snake River, Truckee River	Early april to october (Martin 2006)	14794-16121	15457.5	Above Willamette Falls, Chinook Fresh
Odocoileus hemionus	Deer	Kelly 1995	Widely Distributed (Eder 2002)	Great Basin	Year round	17,971-31,450	24710.5	
Oncorhynchus tshawytscha	Salmon	Plew 1983, Lindstrom 1996, Butler and Martin unpublished, NOAA 2009, Martin 2006	Aquatic	Willamette Falls	Early april to october (Martin 2006)	35635.87	35635.87	At Willamette Falls, Chinook Dried
Oncorhynchus tshawytscha	Salmon	Plew 1983, Lindstrom 1996, Butler and Martin unpublished, NOAA 2009, Martin 2006	Aquatic	Willamette Falls	Early april to october (Martin 2006)	87441.37	87441.37	At Willamette Falls, Chinook Fresh
order Orthoptera	grasshopper	Lindstrom 1996		Great Basin		27,649-272,668		Not this abundant in Willamete
Madia sativa	Tarweed	NA	NA	NA	NA	NA	NA	Unable to find
Ursus americanus	Black Bear	NA	NA	NA	NA	NA	NA	Unable to find
Cervus elaphus	Elk	NA	NA	NA	NA	NA	NA	Unable to find
Lampetra spp	Lamprey	NA	NA	NA	NA	NA	NA	Unable to find
Division Ditrysta	Caterpillar	NA	NA	NA	NA	NA	NA	Unable to find

Appendix C. Hazelnut OFM Calculations

Hours (1 person) for 100 kg
1277
100 kg equals (g)
100,000
number of 100 g packets
1000
kcal per 100g
628
total kcal
628000
kcal / hr
491.7776038

Appendix D. Chinook Salmon Return Rates at Willamette Falls

Number of people	Number of Hours	Salmon per hour	Mean adult weight (kg)
1	12	20	13.61
	Salmon per day	**Salmon weight per day (kg)**	
	240	3266.4	
	Kcal per 100 g smoked	**Kcal per 100 g fresh**	
	176	222	
	Kcal per kg smoked (100g x 10)	**Kcal per go fresh (100g x 10)**	
	1760	2220	
	Total calories smoked	**Total Calories fresh**	
	5748864	7251408	
	Smoked handling ratio (hr/kg)	**Immedate consumption handling ratio (hr/kg)**	
	0.024-0.058	0.010-0.024	
	Mean ratio value	**Mean ratio value**	
	0.041	0.017	
	Smoked Consumption processing time	**Immediate Consumption Processing time**	
	133.9224	55.5288	
	Manufacturing costs		
	Spear		
	4		
	Bag Net		
	11.4		
	Total		
	15.4		

Summary	
Total hours smoked (Capture, handling, manufacturing)	**Total hours fresh (Capture, handling, manufacturing)**
161.3224	82.9288
Kcal per hour smoked	**Kcal per hour fresh**
35635.86954	87441.37139

Appendix E. Chinook Salmon Return Rates Above the Falls

Processing Cost per Kg

Fresh	**For Storage**
Max	**Max**
0.049	0.118
Min	**Min**
0.038	0.093
Hrs	
max	**max**
289.4606498	697.0685036
min	**min**
224.4796876	549.3844986
Total hours processed	
min	**min**
813.4796876	1138.384499
Max	**max**
886.4606498	1294.068504

Fresh **Post Processing Kcal / hr**	**Dried** **Post Processing Kcal / hr**
min	**min**
14794.04602	8034.314971
max	**max**
16121.28716	9133.077589

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