

AN ABSTRACT OF THE THESIS OF

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Title: A Reconstruction of Plant Species Composition at the Devil's Kitchen Site (Southern Oregon Coast) using Plant Opal Phytoliths and Charcoal Macro-remains.

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Leah D. Minc

Although plant remains, such as opal phytolith and charcoal analyses, have been used since the beginning of the 20th century to reconstruct past environments by ecologists and botanists, only recently have these techniques been considered by archaeologists in understanding the past at the site level. This study employs opal phytolith analysis with charcoal analysis to determine both the plant community composition and the possible use of tree species by humans at the site of Devil's Kitchen (Southern Oregon coast) across the time interval of ca. 11,600 to 1,900 Radiocarbon Years Before Present (RCYBP). A total of 44 phytolith sample slides and 73 charcoal samples were analyzed from 5 lithostratigraphic units representing different depositional environments reflecting the site's distance from the ocean and elevation above sea level. This is due to the dynamic nature of landforms on the Oregon Coast, which since the last glacial maximum, have been influenced by sea level rise, tectonic uplift, and coseismic subduction. This dynamic landscape is confirmed by the botanical evidence. Charcoal

macro-remains from the oldest sediments ($10,638 \pm 35$ to $11,698 \pm 38$ RCYBP) indicate a forest of Douglas-fir and western hemlock. Phytolith evidence from later sediments ($4,274 \pm 26$ to $1,901 \pm 28$ RCYBP) shows first, a mixture of saltwater inundation tolerant saltgrass and non-inundation tolerant fescues, followed by a period of time when only saltgrass is present. The site then returns to a mixture of saltgrass and fescue (ca. 2101 ± 23 RCYBP), until the site is buried by sand dunes. This updated perspective on the plant species surrounding the site through time provides important information on habitat and resources, and will assist archaeologists in interpreting other aspects of the archaeological record by placing artifacts in the environmental contexts in which they were used.

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A Reconstruction of Plant Species Composition at the Devil's Kitchen Site (Southern
Oregon Coast), using Plant Opal Phytoliths and Charcoal Macro-remains

By
Nicholas H. Bulder

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Approved:

Major Professor, representing Applied Anthropology

Director of the School of Language, Culture and Society

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request

Nicholas H. Bulder, Author

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Chapter 1. Introduction

Humans have always been very closely dependent on the environment that sustains them. For hunter-gatherers it was crucial they had a good understanding of the environment to know when and where resources would be available to exploit; as archaeologists in the present it is thus important to understand what this environment was like to interpret the archaeological record. While modern humans may try to create artificial environments or to engage in niche construction for enhanced environments (Laland and O'Brien 2010), hunter-gatherer societies looked to find environments that provided the necessary natural resources to sustain their lifestyles, and when a locality is exhausted of those resources they moved to a new area (Kelly 2007: 111-150).

The Pacific Northwest of North America is remarkable for its abundance in resources, berries, camas, fish, shellfish, marine mammals, and birds for food; added to this cedar trees for construction of large plank houses and ready sources of tool stone, including: cryptocrystalline silica, nephrite, and obsidian (Ames and Maschner 1999). This has allowed Native Americans in this area to form corporate units Ames and Maschner (1999) term household domestic units. Because of this stability and abundance these corporate units were able to establish themselves permanently to locals; moving not when local resources were exhausted, but moving when environmental changes, such as sea level rise or tectonic action, moved these highly abundant resource locals to other areas in the landscape. Even so, these resources, however abundant and

accessible, are only available at specific times of the year and some are only at specific places in the landscape (Suttles 1968). So, if our aim is to interpret hunter-gatherer and the later more complex villages of the Pacific Northwest's lifeways and their adaptations, we have to have an understanding of the specific natural environment in which they chose to live (Kelly 2007; Moran 2008).

For example, the forests west of the Cascade Range in the Pacific Northwest are some of the most biologically productive in the world (Franklin and Dyrness 1973); however, very little of this forested biological productivity offers humans very much to eat.

Contemporary researchers in ecology especially in the 19th and 20th century have concentrated on forest production because this was the primary economic interest of this area for Euro-Americans (Robbins 1997), but for Native Americans other landscape types were probably more important. These would include grasslands, estuaries, tidelands, and others areas that could be utilized for food production (Suttles 1990).

Devil's Kitchen (35CS9), an archaeological site on the Southern Oregon Coast, figure 1.1., has been occupied since the early Holocene (Hall 2005). This means there is the possibility this site can open a window into the kinds of environments early and later Native American chose to inhabit. To that purpose, this study seeks to reconstruct the habitat, in terms of the plant species composition immediately surrounding the site of Devil's Kitchen; with the purpose of determining the kinds of natural environments humans gravitate towards. With this framework in place it would then be possible to determine the likelihood that humans occupied an area based on the plant micro-

remains taken from sediment cores without the need for a larger excavation. Sediment cores can even be taken in areas where normal methods of site location such as, pedestrian survey and shovel probes are impossible; places offshore that have been submerged by rising sea levels during the end of the last ice age.

Devil's Kitchen currently sits on a bluff overlooking the Pacific Ocean. Ecologically this site is situated on the northern terminus of the "California vegetation zone" (Minor 1986). The Coquille River drainage is considered the dividing line between the more forested Northern and Central Oregon coasts of the Pacific Northwest vegetation zone and the grass, herb and shrub dominated coastline of the California vegetation zone. *Tsuga* (hemlock) and *Pseudotsuga* (Douglas-fir) stands are typical in the California vegetation zone just inland in Southern Oregon and Northern Californian coasts, while in the Pacific Northwest zone, these forests would be seen adjacent to the coast (Minor 1986). The underlying geology of this area results in a perched water table on the sandy soils allowing for the creation of cranberry bogs and grasslands that extend east to Myrtle Point. South just past Floras Lake, grasslands support a thriving beef and dairy industry.



Figure 1.1. Map of Devil's Kitchen and approximate location on the Oregon coast.

Earlier reported radiocarbon dates (Hall *et al.* 2005) suggest that the Devil's Kitchen site was potentially occupied since $11,000 \pm 140$ radiocarbon years before present (RCYBP) up to the early contact period (Dale 1917). This makes this site important in studying Native Americans because it potentially spans from the terminal Pleistocene through what Ames and Maschner (1999) term the Early, Middle and Late Pacific Periods. Humans arrived in the Pacific Northwest near the end of the Pleistocene, at least by 11,500 radio carbon years before present (RCYPB). Evidence for this is seen at Paisley Five Mile Caves, Oregon (Jenkins *et al.* 2012), Fork Rock, Oregon (Aikens *et al.* 2011) and Cooper's Ferry, Idaho (Davis and Schweger 2004). Human occupation along

the Oregon Coast during the late Pleistocene and into the early Holocene is also found at sites such as Indian Sands (Davis *et al.* 2004; Davis 2006), and Tahkenitch Landing (Minor *et al.* 1986). However, relatively little is known about the environments these early sites offered for human occupation.

There have been a few environmental reconstructions in the Pacific Northwest using pollen cores (Heusser 1960; Heusser and Balsam 1977; Heusser *et al.* 2000). These have resulted in reconstructions that view landscapes at a coarser spatial resolution than is relevant for considering specific sites. Trees produce more pollen than other plants and its dispersal is often airborne as opposed to being dispersed by vector insects. The results of this are that an environmental reconstruction based on this method doesn't capture what much localized environments are like. There are also biases in what is considered important for study, and ecological research has been geared towards resource extraction and in Western Oregon this means trees for lumber (Franklin and Dyrness 1973). These factors have produced studies that are very descriptive of forest composition over time in regards to tree species but often list plant species more utilizable by humans as "other" or "herbs" (Heusser and Balsam 1977; Heusser 1998; Thompson and Anderson 2000; Williams *et al.* 2004). The "other" in this sense is areas important to human occupation that include marshes, grass balds, sand dunes and estuaries.

The aim of this study then, is to reconstruct the environmental conditions, in terms of plant species composition, using more specific and localizing methods surrounding the

archaeological site of Devil's Kitchen. As well as, how the nature of the human occupation might have changed over time as the plant community composition changed at this site as sea levels rose from the terminal Pleistocene through the Holocene. Plant opal phytolith analysis was chosen as the method for determining the background plant species composition because, being made of silica, phytoliths preserve well over time and they do not move around within the landscape from where they are deposited (Rovner 1986). Charcoal analysis is used as a second line of evidence. Charred organic matter also survives well and can be used to identify the species of tree it was made from. Although charcoal can form naturally, it is also formed culturally as it is an almost daily need for humans to make cooking fires, and in the Pacific Northwest the fuel for those fires is wood. Even though, the presence of charcoal cannot always be tied directly to human presence or use because it is also formed by natural events there are instances when it can be reasonably inferred. Evidence for this would be the presence of other objects such as features, hearths, and artifacts associated with cooking, these give a strong argument that charcoal associated with those objects are cultural.

Plant communities and a changing climate on the Oregon coast

As the Pleistocene transitioned to the Holocene consequential changes to the climate occurred, including rising sea levels that inundated landscapes formally occupied by Native Americans also rising CO₂ levels, and changes in precipitation, and temperature that affected plant communities (Heusser 1960). What do we know of the plant composition of the southern Oregon coast from the end of the Pleistocene to the

present? At present, Franklin and Dyrness (1973) place the Oregon coast in what they term the “*Picea sitchensis* (Sitka spruce) zone”. Geographically, the *Picea sitchensis* zone is a long narrow strip that stretches the length of the coastal areas of the states of Washington, Oregon and northern California; this strip extends only a few kilometers inland from the coastline, although it does extend further east following along the sides of rivers. The dominant tree species in this zone consist of: *Picea sitchensis* (Sitka spruce), *Tsuga heterophylla* (western hemlock), *Thuja plicata* (western red-cedar), *Pseudotsuga menziesii* (Douglas-fir), and *Abies grandis* (grand fir). *Alnus rubra* (red alder), the main deciduous tree species in this zone, is common along rivers and creeks and in disturbed areas; *Alnus* is also the primary pioneering tree species after a fire. Common forest understory vegetation, defined here as any plant growing below the dominant species (Franklin and Dyrness 1973), in the *Picea sitchensis* zone are: *Polystichum munitium* (sword fern), *Oxalis oregana* (sorrel), *Maianthemum dilatatum* (May-lily), *Montia sibirica* (Siberian miner’s lettuce), *Tiarella trifoliata* (threeleaf foamflower), *Viola sempervirens* (redwood violet), *V. glabella* (stream violet), *Disporum smithii* (Smith’s fairybell), *Vaccinium parvifolium* (red huckleberry) and *Menziesia feruginea* (rusty menziesia) (Franklin and Dyrness 1973; Hitchcock and Cronquist 1973).

In the more recent *Flora of Oregon: Volume 1*, the ecological overview (Albert 2015) provides a more nuanced, less resource extractive definition of the *Picea sitchensis* zone. Referring to it as the estuarine coast, it looks at the ecology of sand dunes, marshes,

swamps and tidal estuaries within this zone. This volume identifies the common salt marsh and estuary species to include: *Carex lyngbyei* (Lyngbye's sedge), *Deschampsia cespitosa* (tuffed hairgrass), *Distichlis spicata* (saltgrass), *Juncus balticus* (Baltic rush), *Sarcocornia perennis* (saltwort), and *Triglochin maritima* (arrowgrass). Sand dune plants are subject to some levels of salt in sea spray but they are also subject to shifting sands and periods of burial. Species that survive in this environment are: *Abronia latifolia* (yellow sand-verbena), *Calystegia soldanella* (shore bindweed), *Festuca rubra* (red fescue), *Glehnia littoralis* (beach silvertop), and *Lupinus littoralis* (seashore lupine) (Albert 2015).

Finally, although Oregon currently does not have a well-developed coastal plain today, during the Pleistocene it had an extensive coastal plain (Davis 2009). It is not exactly clear what this Oregon plain would have looked like; however, Washington State retains some coastal plain and it could stand in as a proxy for areas further south, if even an imperfect one. Franklin and Dyrness (1973:69) describe the plant composition of the Quillayute prairie, a coastal plain in the western Olympic Peninsula as follows: "The prairie is primarily dominated by *Pteridium aquilinum* (bracken fern), associated with that is *Achillea millefolium* (yarrow), *Anthonanthus odoratum* (vernalgrass), *Eriophyllum lanatum* (Oregon sunshine), *Fragaria vesca* (wild strawberry)".

Compared to their characterization of grasslands and grass balds in the western Coast Range of Oregon, the major species consists of *Danthonia californica* (California oatgrass), *Stipia* spp. (needle grass), *Agrostis hallii* (Hall's bentgrass),

Agropyroncaninum(slender wheatgrass), *Bromuscarinatus*(California brome), *B. vulgaris* (Columbia brome), *Elymusglaucus*(blue wild rye), *Festucaoctoflora*(six-weeks fescue), *F. californica*(California fescue), *F. rubra*(red fescue), *F. occidentalis*(western fescue), and *Molicasubulata*(Alaska oniongrass) (Franklin and Dyrness 1973) that these two areas are distinct enough and that the plant species found today on the Southern Oregon coast are going to be the same species found in the late Pleistocene.

Potential influences of climate change on plant communities

There are several mechanisms by which Pleistocene climate would affect plant distribution. One of the most important is that lower CO₂ levels give plants that use the C4 photosynthetic pathway (such as many grasses) an advantage over plants that use the C3 photosynthetic pathway (such as trees). Alastair Fitter and Robert Hay (2002) explain that this is because the carbon fixing enzyme, rubisco (ribulose biphosphate carboxylase oxidase), is not very good at discriminating between carbon in CO₂ and atmospheric O₂. In photosynthesis, the process of converting CO₂, H₂O and light energy, in the form of photons, into energy plants can use, rubisco is the enzyme that fixes carbon within plants' chloroplasts, the cells in plants where photosynthesis takes place. When air enters a plants leaf through openings called stomates, what is designed to happen but not always, is that the enzyme rubisco will fix the carbon from carbon dioxide, but occasionally rubisco will fix O₂ in a process called photorespiration. Photorespiration is, essentially, reverse photosynthesis and plants have to use a lot of energy to reverse the products of photorespiration. It is, potentially, an evolutionary

disadvantage to have a (normal) C3 photosynthetic pathway. Plants that have evolved with a C4 pathway first take the CO₂ from the air that enters the stomates and fix it with the enzyme phosphoenolphosphate carboxylase (PEP). The carboxylic acid that is produced travels to structures called “Kranz” anatomies that surround the chloroplast containing the rubisco. This essentially minimizes the chances of photorespiration (Fitter and Hay 2002). This pathway also requires more energy from plants and also has some evolutionary disadvantages.

So how does this fit into the narrative of changing plant communities? It would seem that plants with the C4 pathway (which are mostly grasses) would have evolutionary advantage over plants with a C3 pathway (mostly trees) in cases where there are low CO₂ concentrations (Bonan 2008) and where temperatures are higher and growing seasons are longer (Stillet *al.*2003). Conversely, in places like coastal Pacific Northwest where plants are not water or heat-stressed, C4 plants do not have a competitive advantage, in this area we find that mostly all grasses and trees have the C3 photosynthetic pathway.

The implication of this is that major shifts in climate would not have a direct effect on plant species composition of a particular site. Instead, forces particular to a site that are subject to change in a dynamic landscape such as, soil conditions, tectonic uplift, subduction, and proximity to the ocean. It is conditions such as these that would seem to have a greater impact on plant species growing at a particular site in this estuarine coast.

Methods for reconstructing past plant communities

As we move into the past it gets more difficult to determine plant community composition because we can't directly survey the species present. We can make assumptions based on evolutionary data and climate conditions from past times (Loehle 2007) or we can use paleo-botanical data closely linked to plants that were existent near the area in question. Two of these methods are using plant opal phytoliths and pollen grains (Heusser 1998; Twiss *et al.* 1969). In this literature review, no phytolith studies were found for the southern Oregon coast. For pollen studies, Linda Heusser (1998) took a series of oceanic cores for the purpose of pollen analysis of plant composition change over time. The study area extended from 32°54.92'N to 46°04.00'N latitude. The core identified in this study as Y7211-1 at 43°15.74'N is very close to the latitude of Devil's Kitchen at approximately 43°8'N (see map, Appendix 1). In Heusser's study the pollen from Oxygen Isotope Stage 3 (OIS3) 59-24 thousand years ago (kya) suggests that ≥90% plant composition consisted of *Pinuscontorta*, *Tsugaheterophylla*, *Piceasitchensis* and herbs, although this report doesn't indicate what species the "herbs" are representing. The species composition for OIS3 shows a progressive decrease in *Tsuga* and an increase in herbaceous plants. This study then suggests that the coastal landscape started the last ice age forested but then changed to a more open parklike environment resembling the higher altitude meadows of the Coast Range of Oregon by the last glacial maximum around 27,000 years ago.

During the period Heusser (1998) calls the Last Glacial Interval (LGI) 24-14 kya, *Quercus* (oak) and *Alnus* (alder) increase, as well as *Tsugaheterophylla*. Increases in *Alnus* are a sign of disturbance or change because this is a pioneer species that rapidly colonizes after fire and floods. Finally, during the time period referred to as the Glacial-interglacial transition (GIT) 14-10 kya (Heusser 1998), the pollen cores show the maximum amount of *Alnus* pollen at the beginning followed by shifts to the modern Holocene forest type as previously described by Franklin and Dyrness (1973).

Although analysis of pollen in lake and bog cores gives a good indication of regional environmental conditions, it is constrained by the total number of pollen producing plants in a region and how far that pollen might travel by wind. It does not have sufficient spatial resolution to discern the plant composition of small distinct archaeological sites or how that plant composition might be attractive to Native Americans. While phytolith analysis offers greater spatial resolution, it also has its drawbacks. While trees produce more pollen than grasses do, grasses produce more phytoliths than do trees; so relying solely on either technique can lead to misleading results. This is overcome by considering other lines of evidence in conjunction with the phytoliths; for example, Nelle *et al.* (2010) state that although pollen analysis reveals vegetation change on a local and regional level, it is not very good on the site specific level. In contrast, whereas charcoal analysis is good at site-specific species composition, it has a weakness in that wood is used by humans, and that brings up the possibility of contamination for studies specifically concerned with environmental reconstruction

because humans can bring wood species to a site from elsewhere in the landscape. Using two lines of evidence, then, will have the effect of cancelling out the weaknesses in each (Nelle *et al.* 2010). This study, however, will use the site specificity of phytolith analysis, and Nelle's stated "weakness" of charcoal analysis to determine if there is a window into past human activities in regard to wood use. My expectations are to find that wood charcoal recovered near fire cracked rock was brought to this site from somewhere else in the landscape.

Organization of this Study

Chapter 2 reviews the literature on paleo-ethnobotanical research relevant to early hunter-gatherer populations in the Pacific Northwest. It discusses the importance of plant material for humans as a source of food, medicine, and fuel. The chapter reports on the usefulness of plant material for interpreting the archaeological past giving examples using pollen and phytolith as well as charcoal analysis. This is followed by an overview of the frequency of natural fires on the coast, as well as, a brief summary of what is believed to be the cultural development of the people living in the Pacific Northwest in the time range of this site's occupation.

Chapter 3 details the history of excavations at the site of Devil's Kitchen (35CS9). It begins with the site's initial description by Lloyd Collins (1951), and covers the different theories of the site's use and who might have been its occupants. This chapter also details the most recent excavations, which was utilized as a source of data for this study.

Chapter **4** describes the field and lab methods for botanical analysis. This chapter explains the sampling strategy and how paleobotanical samples were collected in the field. It details the laboratory methods used to process the sediment and plant samples. Included in this chapter are the sampling and creation of comparison collections, extracting phytoliths from soil sediments and the methods used in identifying wood charcoal to genus and species, when possible.

Chapter **5** presents the analysis of botanical remains. Here the results of the laboratory analysis are reported. These include phytolith counts by level and their species composition, charcoal counts and species composition as well as radiocarbon dates for the charcoal, and evidence for the presence of aquatic micro-remains.

Finally, Chapter **6** summarizes the interpretations and conclusions. This chapter interprets the results from chapter 5 showing how the paleobotanical evidence can be an indicator of the overall environmental context. It covers plant succession through different landscapes, the influence of the proximity to the littoral zone, fire, tectonics, and how these factors relate to how humans may have been using this site.

Chapter 2. Literature Review of Paleoethnobotanical Research

Paleoethnobotany is more than just the study of plants that past cultures exploited. Since plants permeate every aspect of human existence, it is at the interface of human thought with nature (Ford 1978). Paleoethnobotany aims to identify which plants were significant and to elucidate how cultures identified, classified and related to them; and how their perception of the environment guided their actions (Ford 1978). Humans play an ecological role as a keystone species wherever they are found (Delacourt and Delacourt 2004). Throughout human history people have used plants for food, medicine, fuel, and technology (Ames and Maschner 1999; Delacourt and Delacourt 2004). Among these uses perhaps the most overlooked aspect is the strategies around the use of plants for fuel (Heizer 1963). All this plant use is tied directly to the environment, because the environment determines which plants are available for use by people and whether by natural conditions or human agency the environment and thus nature of plant exploitation changes over time.

The importance of plant materials for interpreting the past

How important was plant material to native peoples in the Pacific Northwest?

Excavations at the Ozette site in Washington State have shown that up to 90 percent of Northwest Native American material culture is based on plant material (Ames 2005).

Ozette was a Makah village in Neah Bay on the Olympic Peninsula, Washington State that was buried in a mudslide in the 15th century. What was preserved was all the

material culture based on plant material, longhouses, canoes, paddles, baskets, blankets, cordage and food.

Traditionally, it has been believed that organic material decomposes and, except under anaerobic circumstances, such as the case with Ozette, it is unlikely that any organic matter would be found, other than charcoal for radiocarbon dating, which would be useful in interpreting an archaeological site. This belief has led archaeologists in the past to not plan for botanical recovery when planning archaeological excavations. This trend is revealed by Lepofsky *et al.* (2001) in a paper enumerating the low profile that paleoethnobotanical studies have in both the literature and in the minds of archaeologists about how such studies can bring insights onto the interpretation of sites.

To counter this belief, Lepofsky shows how plant remains can be used to better understand the archaeological record, even in the Pacific Northwest (Lepofsky and Lyons 2003). Their study, situated in the Coast Salish region, utilizes ethnographic data to model different degrees of sedentism, such as, short term camps, base camps and villages. In this report they state that archaeologists have used lithic assemblages, features and faunal remains to determine site use but have not paid much attention to botanical remains. They argue that with as much ethnographic knowledge as there is for plant use in the Pacific Northwest botanical remains should also be used to determine site function.

One example of the value of ethnobotanical insight comes from Losey and colleagues (2003), who use the presence and abundance of charred *Sambucus racemosa* (red elderberry) seeds to determine use and seasonality at a site in Tillamook County, Oregon. Likewise, Bonzani (1997) uses plant diversity in the archaeological record to determine mobility strategies at the site of San Jacinto 1 in Northern Columbia. This study employed optimal foraging and risk management theories to draw their conclusions. This study concluded that the site was a specialized base camp based on the fact that nearly 100% of the recovered plant remains were seeds from a single class of species (grasses, *Poaceae*) as well as *manos* and *metates*. This conclusion uses the concept of redundancy in the macrobotanical record: specifically, they argue that natural systems would have a higher degree of diversity and low redundancy representing more different types of plants, while a more specialized site for processing plants would have lower diversity and greater redundancy of plants remains and artifact forms. By these criteria, a residential camp would have more diversity and less redundancy than a special purpose camp (Bonzani 1997). The Shawnee-Minisink site in Pennsylvania is a Clovis site. Here Gingerich (2011) used plant micro-remains in sediments from that site to show that Clovis people were not exclusively big game hunters, but also acquired a substantial portion of their diet from plants. This site relates to Pacific Northwest sites in that it demonstrates how important plant material was to early hunter-gatherers.

The use of Phytoliths in environmental reconstructions

Even though phytoliths have been studied in Europe (especially in Germany) since the 1890's, it was only relatively recently that phytolith studies have been carried out in the United States. Twiss and colleagues (1969) conducted one of the first phytolith studies in the United States to recreate past environments of the North American Midwestern grassland by extracting phytoliths from sediments. This study also created one of the first phytolith classification systems by separating phytoliths into four classes: Festucoid, Chloridoid, Panicoid and the elongate class. In this classification system, the Festucoid, Chloridoid and Panicoid are defined based on morphology of the short cells within grass stem and leaf structures that are distinctive between different groups of species. The elongate in contrast is indistinguishable other than they belong to grasses (Twiss *et al.* 1969). Blinnikov (2005) showed that species other than grasses produce identifiable phytoliths, such as conifers, sedges, and some shrubs. His study, from a survey conducted at the east side of the Cascade range in Washington State, expanded on Twiss's four classes to include trees and to try to associate different phytolith morphologies with individual species, not just classes of species. On the West side in the Pacific Northwest at Vancouver Island, British Columbia, McCune and Pellatt (2013) used phytoliths to determine how forests have shifted over time, again using phytolith morphological types from grasses or trees from soil sediment samples to see how plant species composition has changed over time.

Charcoal's natural and human genesis

Archaeological conclusions have more validity when using different but concurring lines of evidence. Charcoal can be created naturally as by lightning strike fires, or by humans, for cooking or clearing land. The archaeological evidence of land clearing fires is hard to distinguish because that evidence is similar to natural fires. Forests in the Pacific Northwest have evolved with fire and are dependent on fire for regeneration; this is evidence that naturally caused fires have been part of this area's ecosystem for a long time. Keeley (2002) studied the impacts of fire in the Coast Range of California, although this study is from California, the weather patterns from central California and southern Oregon is similar enough to make general conclusions. His finding shows that conditions on the coast are such that storms that produce lightning during the summer on the coast are extremely rare. This is because of cold-water upwelling that comes in contact with warm summer air generates fog (Pisias *et al.* 2001); this fog in turn keeps the plants and dead plant parts moist enough in most years to prevent burning. Keeley's study does show that a natural fire on the coast would occur about once every hundred years; coincidentally this corresponds closely to the life cycle of *Pinus contorta* var. *contorta* (shore pine) which is highly fire dependent for regeneration. Keeley suggests that evidence of fire on the coast with a greater frequency than what is considered natural should be an indication of human agency.

Asouti and Austin (2005) assert that using charcoal macro-remains for environmental reconstruction is not very accurate because of the nature of how different species of

wood charcoal preserve in the archaeological or environmental record from the past to the present day. They do, however, say it can be a powerful tool to determine prehistoric wood fuel use. These authors theorize that mobile Hunter-Gatherers would use the “least effort” method in gathering firewood. That means to them, that hunter-gatherers would tend to gather dry dead fuel wood from the ground, nearest to their camp sites. Demonstrating this, Asouti(2003)found that Neolithic and early Chalcolithic groups in south-central Turkey exploited a wide range of available tree species. The lack of evidence that some species were being depleted was interpreted to mean that these groups didn’t have a preferred species and that they moved on before foraging pressure for fuel wood depleted that resource.

Theories of fuel wood acquisition

Marston (2009) creates a model to test aspects of wood fuel acquisition based on behavioral ecology theory. This theory’s main basis is that people will assign a value to various activities in terms of the amount of energy expended versus the amount of energy gained and that these behaviors will optimize the amount gained. In terms of fuel wood, Marston uses energy content. By this he is referring to the amount of BTU’s (British Thermal Unit, the amount of energy required to raise the temperature of one gallon of water one degree Fahrenheit) the wood transfers when burned. This is a factor of its water content, resin/oil content, and density. In gathering fuel wood, energy expended is measured in terms of distance traveled and the amount of effort required to pick up or chop down branches. Heizer (1963) discusses this principle while

combining ethnographic data from around the world in regards to fuel wood acquisition strategies. In this study, ethnographies from Drucker (1951) and Kroeber (1951) specifically inform Heizer on fuel wood gathering strategies in the Pacific Northwest. Heizer's conclusions are that mobile hunter-gatherers prefer readily available dry dead branches that can be easily gathered not far from the camp site, confirming Marston's model from behavioral ecology. Also, when an area's fuel source is exhausted, hunter-gatherers will move to another location even if food sources in that area are still plentiful.

Wood Fuel use in the Pacific Northwest

Ames separates the prehistory of the Pacific Northwest into four periods: the Archaic, 11,000 to 5,600 RCYBP; the Early Pacific, 5,600 to 3,400 RCYBP; the Middle Pacific, 3,400 to 300 RCYBP and the Late Pacific Period from 300 RCYBP to the Contact period with European and Euro-Americans. Radiocarbon dates from the levels that indicate occupation at Devil's Kitchen range from approximately 11,600 to 1900 RCYBP, so the activities from this site have the potential to reflect different subsistence activities as they changed through time (Ames and Maschner 1999). Radiocarbon dates from the site date the main occupation from the Early Pacific to the Middle Pacific cultural periods. In the Early Pacific period, sites in coastal Oregon and Washington show sporadic use of shellfish with increasing frequency of utilization as pit house sedentism increased. The Middle Pacific period saw the development of villages with plank houses. Near this location there was a village (35CS5) nearby on Bandon spit. The

people from that village may have used this site, at Devil's Kitchen has a source of tool stone and would have been visited frequently. If this were the case it would be expected that visits would be short with small and ephemeral features and cooking hearths reflecting not an occupation but a nonresidential work site.

Summary

In summary, even though the literature from this review doesn't specifically involve the Southern Oregon coast, it does point to it being possible to being able to recreate the environment of a specific site by combining phytolith analysis with charcoal analysis. It may also be possible to get a glimpse of cultural practices in regards to utilizing plant life at that area.

Chapter 3. History of archaeological excavations at Devil's Kitchen

The Devil's Kitchen site (35CS9) is located within the Oregon State Park system; previously it was part of a series of small parks known as Bandon Ocean Wayside on the Southern Oregon Coast. This site has been surveyed for archaeological material and site conditions four times before 2009; the most recent effort has been led by Dr. Loren Davis from Oregon State University. The site was first identified by Lloyd Collins in 1951. He characterized it as an open bluff site and noted chert flakes eroding out of a black pebbly matrix, and postulated that the site had had a shell midden but it had been stripped off by erosion (Collins 1951). This assumption about the eroded and therefore missing shell midden was rooted in the belief that the Oregon Coastline had not changed significantly over time, and that their experience in surveying other coastal sites was that the sites had associated shell middens. Early in the 1970's Richard Ross surveyed the site for Oregon State Parks; he also noted the chert flakes eroding out of the black matrix. Ross, however, believed the lack of a shell midden represented a different, older terrestrial orientated use of the site (Ross 1984). In Ross's view, this site represented people from the interior of the continent moving towards the coast and the archaeological material recovered represented their lifeway before they became adapted to a marine environment. He notes that what he characterizes as "bluff sites" are different in their tool technology as well as the absence of shell middens. Ross (1984) also points out that Kroeber (1917) suggested that Athapaskan speaking people, those who would be today known as the Coquille Indian Tribe and are the

historical occupants of this area, had occupied the southern coast of Oregon only recently (since about the last two thousand years). These sites then, according to Ross, represent an occupation from non-marine utilizing peoples that occurred earlier in time and possibly are not connected to the later groups that occupied this region and produced sites with shell middens (Ross 1984).

In 1986, Rick Minor evaluated 35CS9 during a larger study of Oregon coast sites, and speculated that this site might have long-term research potential. He noted that there were fire-cracked rock and chert flakes eroding from the cliff face but because of landscaping decisions by Oregon State Parks (in the form of a lawn and the paving of a parking lot) they were unable to determine the inland extent of the site by using pedestrian survey methods (Minor 1986). Minor agrees with Ross that there appears to be no shell midden associated with this site and that it contains information about a different aspect of prehistoric occupation (Minor 1986).

In 1993, the site was surveyed by Jon Erlandson and Madonna Moss; they reported in the site form that the site's boundaries could not be determined for the same reasons reported in Minor 1986. Erlandson and Moss report that the cultural level is below eolian sand and within a pebbly alluvial deposit; however no datable material was recovered. In 2000, Roberta Hall and Loren Davis posited that a way to find sites that date to the late Pleistocene and early Holocene on the Oregon Coast would be to first find undisturbed geological deposits that date to that time period (Hall 2000; Hall *et al.* 2005). Because of the nature of the deposits at Devil's Kitchen (comprised of lithics

and fire cracked rock, and not shell and bone as in more recent sites on the coast), and the stratigraphic layer that the cultural material was found in (pebbly alluvium below an eolian sand deposit suggesting that these were deposited before sea level began to rise in the early Holocene), [personal communication from Erlandson and Moss to Roberta Hall in 2001, Hall *et al.* 2005]. Erlandson and Moss recommended Devil's Kitchen as a potential site with intact deposits that date to the late Pleistocene to test a theory of finding pre 10,000 year old sites by first finding sediments that are 10,000 years old or older (Hall *et al.* 2005).

The existence of these "bluff sites" in Oregon they include Indian Sands, Blacklock Point, and Devil's Kitchen has been a mystery to archaeologists because, even though they are adjacent to the coast the artifact assemblage of these sites do not indicate the exploitation of coastal resources. In his book, *Prehistory of the Oregon Coast*, Lyman (1991) puts forth four explanations for the existence of bluff sites. These are: 1) bluff sites were inhabited at the same time as shell midden sites only the bluffs were where the houses were located and middens were the dumps; 2) bluff sites were coastally located sites of interior people who did not know how to exploit marine resources; 3) bluff sites and shell midden sites were occupied by the same people but they represent functionally or seasonally different activities; and 4) bluff sites are chronologically much older than shell midden sites. The unknown nature of these bluff sites is maintained, I believe, by analyzing the archaeological assemblage in isolation and apart from the ecological environment it was produced in.

In 2002 Dr. Loren Davis led test excavations at this site as part of the project to find areas of the landscape that date to the late Pleistocene. In the 2002 excavations, two 1m by 1m units were excavated, labeled A and B. These excavations indicate that the site is well stratified with little to no disturbance in the stratigraphy (Hall *et al* 2005). Radiocarbon dates from this excavation indicate that sand dune accumulation began after 2600 ± 40 RCYBP (Hall *et al.* 2005). Also, lithic debitage and formed stone artifacts were found in association with alluvial sediments that date between 2600 ± 40 and $11,000 \pm 140$ RCYBP (Hall *et al.* 2005; Davis 2010). This test excavation indicated that the site was occupied off and on over a long period of time, into the thousands of years. However, since these initial investigations were limited, the character of the site could not be determined and the age of occupation was bracketed to between 2600 ± 40 to $11,000 \pm 140$ RCYBP (Hall *et al.* 2005).

Current investigation at Devil's Kitchen

Starting in 2009, Dr. Loren Davis led further test excavations at 35CS9, see figure 3.1. To begin, it was planned that up to 50 test holes 50cm X 50cm in size would be excavated to a depth of 50cm, with incremental 10cm arbitrary levels. At the bottom of these shovel test units, augers would be utilized to gain an understanding of the subsurface stratigraphy. Augers were 10cm bucket type augers going to incremental depths of 10cm until the top of a hardened marine terrace was reached. This terrace dates to before human occupation in the Americas at *ca.* 60,000 BP. In all, 31 test pits and auger units were excavated around the Devil's Kitchen wayside (Davis 2010). Of these,

eight produced lithic debitage and a shell, with lithic debitage extending approximately 100 meters inland from the edge of the cliff. The shell was believed to be from a possible midden and has been identified as *Balanus nubilus* (Horse Barnacle).

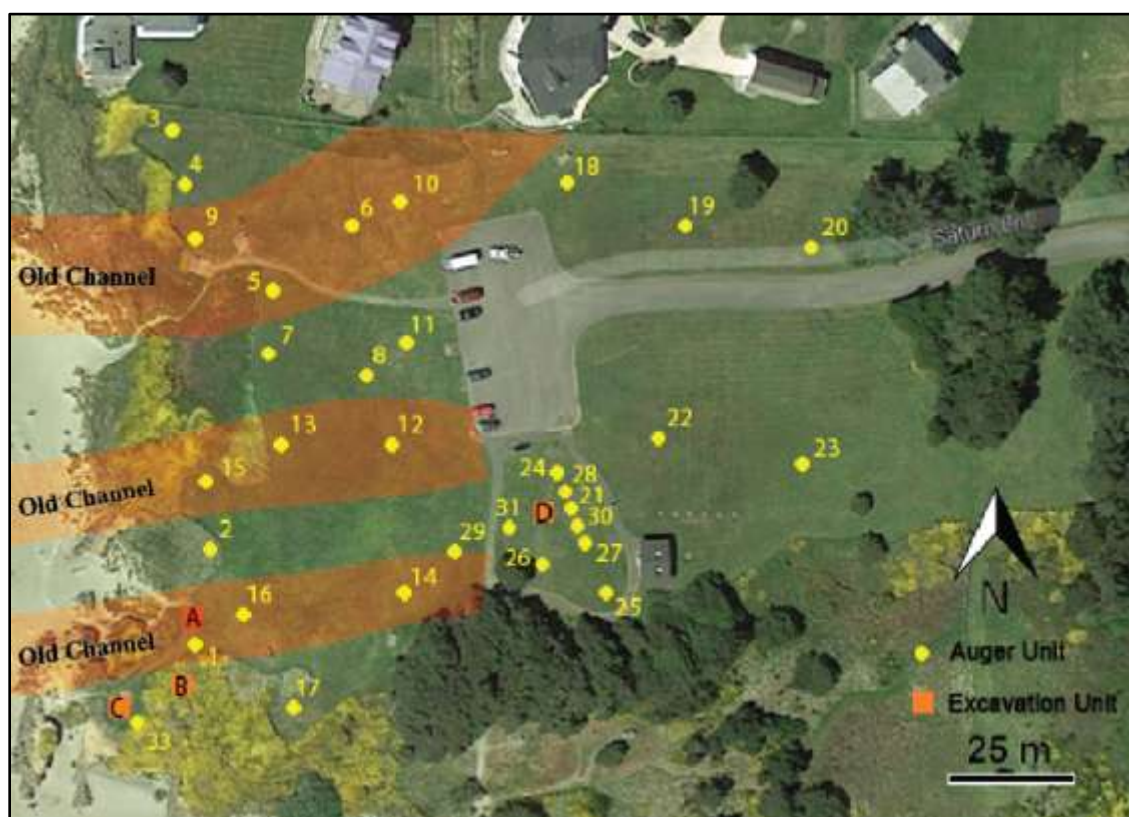


Figure 3.1. Google earth image with superimposed auger test units and excavation units from the current and 2005 excavations. Also included are the theorized old stream channels of Crooked Creek, as identified by Jessica Curteman (2015).

From this subsurface testing, it was decided in 2010 to excavate two larger (2m X 2m) units labeled C and D. Unit D was located on a grassy knoll close to original auger test units 21, 24 and 28 (Davis 2010) where the shell and some lithic flakes were recovered. The purpose of this unit was to further investigate the possible shell midden. The plan was to excavate in 20cm arbitrary levels within stratigraphic units until cultural material started to be recovered, and then excavations would switch to 10cm arbitrary within

stratigraphic levels. In the top layers we exposed many skeet targets in the form of “clay pigeons”; this was a common artifact in the top 20cm throughout the site and might have been associated with an early structure/ house that was located on the Northwest corner of the State Park (Appendix I.II). At around 140cm below datum (BD), the aeolian sand terminated and an O/A horizon of a buried soil was encountered. The main cultural component was found between 170 and 200cm BD, with two hearth features (features D1 and D2) and a whale bone (feature D3) excavated at 200cm BD. Between 240 and 250 cm BD, the top of the marine terrace was reached and we continued to excavate to 266cm BD, at which point excavations were terminated owing to the absence of cultural material in the last four 10cm arbitrary levels. Excavation of Unit D was problematic mostly due to the walls collapsing often. Accordingly, at 150cm BD, we switched from a 2m X 2m unit to a 1.5m X 1.5m unit. Starting at level 20 at 250cm BD the unit was further reduced to a 1m X 1m, and. On the 50 cm bench created by reducing the size of the unit, sand bags were stacked to stabilize the walls.

In Unit D we had expected to find shell as we did in auger unit 24, but we did not. In selecting the position of Unit D, it wasn't considered critical to be directly within auger unit 24 because we suspected a shell midden would be more extensive and we only needed to be close. When no shell was uncovered in Unit D, a new unit (Unit E) was opened where auger unit 24 was located.

Unit E was a 1m X 2m excavation unit located approximately 1.5 meters northeast from Unit D. The unit was excavated using 20cm arbitrary levels within stratigraphic layers.

At about 30cm BD we uncovered a PVC irrigation line that ran along the long axis near the center of the unit; this made excavation of the unit more difficult. From 0-152cm BD the deposits consisted of aeolian sand; below that level, alluvial deposits were encountered to a depth of 160 cm. Near the top of the alluvial deposits, remnants of horse barnacle and fire cracked rock (FCR) were uncovered. In the center of the barnacle was the 10cm auger hole. It appears that instead of a midden, there were one or two shells with some FCR. Excavation of Unit E was halted at 160cm below datum.

Unit C was a 2m X 2m excavation located on the bluff near Units A and B (see Figure 3.2.). As with the other units, we started excavating at 20cm arbitrary levels within stratigraphic units. Within level 3 (50-60cm BD) we encountered FCR and debitage so excavating was changed to 10cm arbitrary levels. At this level the sediment was still sandy; sediments started to transition to alluvial deposits at level 8 (100-110cm BD). The top layers again had skeet shooting targets probably associated with the early dwelling to the southwest of the State Park. In levels 3 through 5 (50cm-80cm BD) a small amount of FCR, debitage and a utilized flake were uncovered indicating a brief, ephemeral occupation while the sand dune that overlays the site was forming. Levels 12 and 13 (137cm-160cm BD) appear to be period of the most intense occupation due to the artifact concentration. However, artifacts were found in every level down to level 24 (260cm-270cm BD) including more formalized bifaces and biface bases throughout these levels.

Figure 3.3. shows the West and North walls of Unit C. The west wall was where the column sediment sample for phytolith analysis were taken and this figure shows the location, excavation level and associated Lithostratigraphic Unit (LU) of each sample. The North wall shows the radiocarbon dates associated with each LU and are shown.

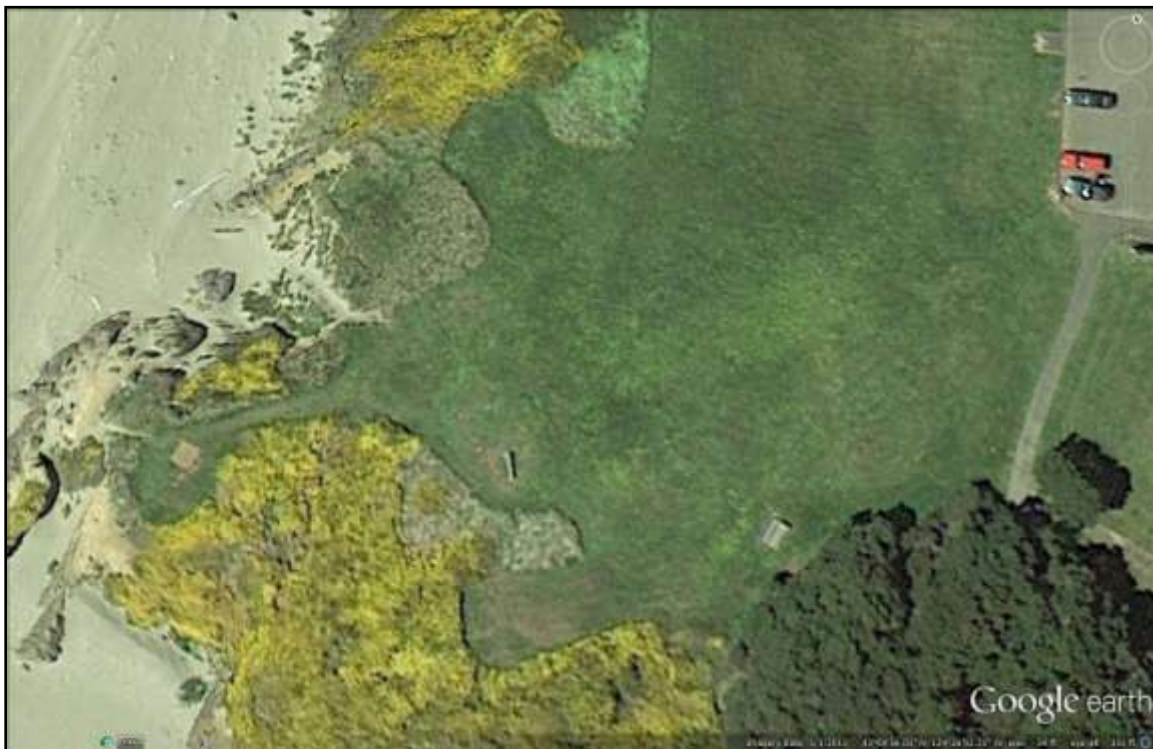


Figure 3.2. Satellite view of Devil's Kitchen State Park. Unit C is the square tan feature on the left hand side of the image, indicated by arrow.

Interpretation of Stratigraphy

Jessica Curteman analyzed the depositional history of the site and, in her thesis describes six lithostratigraphic units from Unit C; these are described from the top of the Unit (modern surface with the highest number designation) to the bottom (Curteman 2015; see Figure 3.3) LU 6 is composed of aeolian (wind transported) sand. No datable

material was recovered, but other dates at the site suggest the dune was formed in the last 2000 years. LU 5 is different from the upper sand dune as it has a greater percentage of silt and clay and the presence of a buried soil. Radiocarbon analysis indicates that this LU dates to between $1,901 \pm 28$ to $9,333 \pm 44$ RCYBP and it contained the majority of artifacts recovered in this unit.

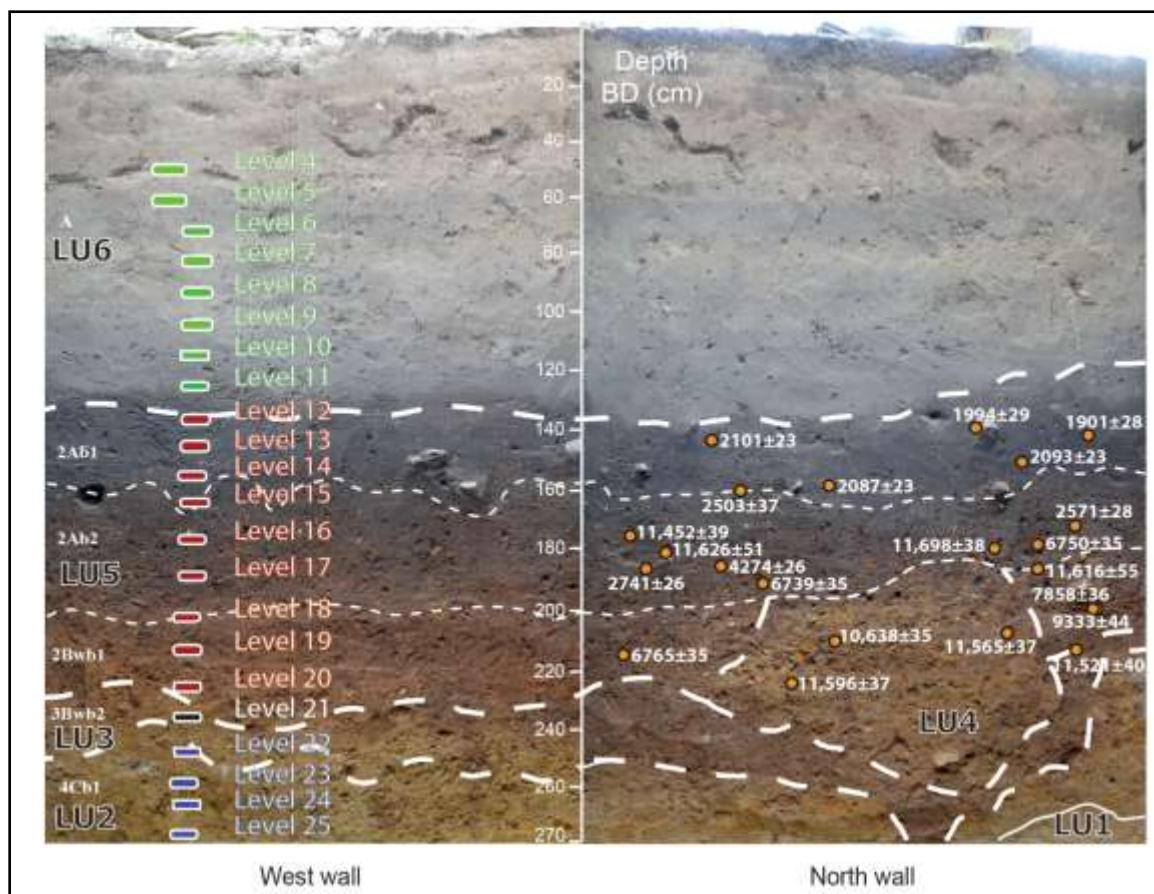


Figure 3.3. West and North walls of Devil's Kitchen Unit C. The North wall shows the Easting positions of the radiocarbon dates and the West wall shows the elevations and excavation levels at which sediment samples were collected for phytolith analysis; as well as indicating which Lithostratigraphic unit (LU) the samples were taken from: Green LU6, Red LU5, Black LU 3 and Blue LU2.

LU 4 is a remnant of older deposits that did not erode away and is dated from $10,638 \pm 35$ to $11,698 \pm 38$ RCYBP. It is theorized that this component was in between two streams that ran into the larger creek nearby. Because of its position and that all the phytolith samples were taken from the West wall this LU was not sampled for phytolith analysis.

LU3 returns to sedimentation with a greater sand percentage than the silt and clay indicating this was from a higher energy depositional environment. Phytoliths were not found in these levels; however, spicules from freshwater or marine sponges were found in LU3. LU2 is again almost 95 percent sand and held no micro remains for analysis. And LU 1 is uplifted marine terrace.

Chapter 4. Field and lab methods for botanical analysis

At the conclusion of excavations at Devil's Kitchen, the West wall of Unit C was sampled for phytolith analysis. A total of twenty-two 100 gram samples were obtained from near the middle of each excavated level (Figures 3.3. and 4.1.) starting at Level 4 and extending down to level 25.



Figure 4.1. Facing west, looking into Unit C at the completion of excavation. Arrow points to column sample for phytolith analysis.

After the Lithostratigraphic Units and excavation levels were mapped on the West wall, sediment samples were collected using a hand trowel that was cleaned between samples. Samples were taken at the approximate middle of each level and within each

LU. Samples were not recovered from LU4 for phytolith analysis unfortunately; this is because the West wall of Unit C appeared to have the best stratigraphic control based on the clearness of the distinctions between layers, and LU4 only appears in the North and South walls. Also, LU4 wasn't identified as a distinct Lithostratigraphic Unit until this thesis was nearing completion. (For details see, Curteman 2015)

Developing comparative collections

The first objective was to create a phytolith comparative collection of Pacific Northwest plants and trees that are common to the coast. Plant specimens were obtained from the Oregon State University herbarium and by field collection by the author. This however did not go entirely as planned. It was by extreme good luck that the author found that the second author in Twiss *et al.* 1969, Dr. Erwin Suess, is professor emeritus at Oregon State University and was gracious enough to guide the author in phytolith classification. For this reason, the classification system developed by P. C. Twiss (Twiss *et al.* 1969) with refinements by Blinnikov (2005) and McCune and Pellatt (2013) was used for identifying phytoliths in sediment samples from the site.

Charcoal preparation from botanical samples

The next objective was to create a comparative collection for charcoal. Wood samples were collected from trees growing at the Oregon coast. Samples were collected by sawing a branch off of the tree. Trees were identified using the key in *the Manual of Oregon Trees and Shrubs* (Jensen *et al.* 2002). Samples were prepared in the lab by

placing them into aluminum bread pans, covering the samples with sand and baking in a muffle furnace at 400° C for 3 hours then allowing them to cool overnight. Samples were imaged using a Keyence digital 3D microscope in a magnification range from 30X to 150X.

Sample preparation of archaeological materials

Phytoliths

Phytoliths were extracted from soil samples using methods adapted from Piperno and Pearsall (Piperno 2010; Pearsall 2010). Since phytoliths are silt sized particles (.05 to .002mm) the process involves removing all the particles that don't fit this size range and then floating the phytoliths into suspension using a liquid with a specific gravity between 1.98 and 2.3 (grams per cubic cm). The sample was first sifted through a no. 60 U.S.A. standard sieve 250 microns (.0098 inches) to remove any sediments that were larger than medium sand (as defined by the USDA Natural Resources Conservation Service). From the sieved sample, 5 grams was measured and placed into a 50 ml centrifuge tube; the tube was then filled with a solution of Sodium Hexametaphosphate and agitated overnight. Tubes were then placed in a centrifuge and spun for 5 minutes at 3000 RPM. This process was repeated until the clay fraction had been removed. The sample was then washed with a 10 percent hydrochloric acid solution (HCl) through a no. 270 U.S.A. standard sieve 53 microns (.0021 inches), to remove the fine and very fine sand fractions, and into a 600 ml Pyrex beaker and heated in a water bath for one

hour; this process was performed to remove any carbonites. The beaker was allowed to sit for two hours to let the silt sized particles settle to the bottom of the beaker and it was then decanted and the sample washed into 50 ml centrifuge tubes. The tubes were then filled with de-ionized (DI) water and spun for 5 minutes at 3000 RPM. These were decanted and washed into 600 ml beakers with a 10 percent potassium hydroxide solution (KOH) and heated in a water bath for one hour; the purpose of this step was to remove any humates. The beakers were allowed to sit for two hours and the KOH solution was decanted. The remaining particles at the bottom of the beaker were washed into 50 ml centrifuge tubes with DI water and spun for five minutes at 3000 RPM. The sample was decanted and this step repeated to wash the sample. After the last washing and decanting the 50 ml centrifuge tube was filled to 30ml with 2.3 Specific Gravity Zinc Bromide (ZnBr) solution. The tubes were then centrifuged for five minutes at 3000 RPM. Using a pipet, two ml of the ZnBr solution was drawn from just below the surface of solution in the 50 ml tube and placed into a 15ml centrifuge tube. The 15ml tube was then filled with DI water to lower the specific gravity of the solution. The 15ml tubes were then centrifuged for five minutes at 5000 RPM. They were then refilled with DI water and this step was repeated three times to rinse the sample. After the last decanting, two ml of acetone was added to the sample tube; the tubes were vibrated and decanted onto watch glasses. The watch glassed were then covered with Petri dish covers and allowed to desiccate. Once the sample evaporated the acetone a small amount of Canada Balsam, as a mounting medium, was added to the center of the watch glass and mixed with a scraper. This mix was then mounted onto a glass

microscope slide; two slides were prepared for each level. A Nikon eclipse E600 PDL polarizing light microscope was used to analyze for phytoliths in both the comparative collection and archaeological sediment samples. Digital images were obtained using an Optix Cam summit series attached to the Nikon E600 and OC view 7 software. It should be noted that in addition to phytoliths, the slides contained many pieces of microscopic charcoal and some aquatic micro-remains.

Charcoal

While excavating at Devil's Kitchen, the provenience of any charcoal found *in situ* was recorded and the charcoal was packaged in aluminum foil; this was to ensure the charcoal would not be contaminated by modern carbon in case it was chosen for radiocarbon dating. The determination of which pieces of charcoal would be recovered in this manner was based on three criteria: (1) sufficient size (i.e., if the charcoal was large enough to be identified, this was determined to be a cross section $\geq 7\text{mm}$; (2) if a piece of charcoal was associated with a feature, regardless of fragment size; and (3) if a piece of charcoal was associated with an artifact, again regardless of size.

All charcoal samples so collected were viewed under an Olympus SF20 dissecting microscope. If it was thought identification was possible, the charcoal was imaged using the Keyance 3D digital microscope and the charcoal was identified as best as possible. Samples sent for radiocarbon dating were chosen using 2 criteria: (1) if the pieces of charcoal represented a unique species, in that the maximum number of different

species was desired; (2) The charcoal also needed to be spaced apart from each other; unless they were associated with a feature or artifact (the charcoal sample sent for radiocarbon dating was too small to identify to being anything other than a conifer).

Chapter 5. Analysis of botanical remains

The analysis of biological material is not always an exact science, especially when those samples are fragmented and damaged from the results of time and fire. Often it is a judgment call, factoring whether a sample has more microscopic characteristics distinctive to one species than another. This is true for closely related genera like *Pseudotsuga* and *Tsuga*; on the other hand, species like *Pinus contorta* are very distinctive, even from other species in the same genus, making identification easier. The same holds true for phytoliths, many shapes are distinctive but others such as the festucoid and chloridoid shapes are similar to each other depending on the angle of view. This being the case, plant remains were identified only to the level that was justifiable for instance, if a sample only revealed enough characteristics that showed it was a conifer as opposed to a deciduous tree, then it was only labeled as a conifer, no further approximations were made.

Phytolith analysis

Using previous studies from Twiss *et al.* (1969), Blinnikov (2005) and McCune and Pellatt (2013), 20 phytolith types from common Pacific Northwest trees, shrubs and grasses were identified. These include the festucoid, chloridoid, panicoid and general grass category from Twiss and Suess (Twiss *et al.* 1969). For a comparison to specific species rather than general classes of species, comparisons to phytolith classes from Blinnikov (2005) and McCune and Pellatt (2013) were consulted. The phytoliths described by

those authors that are used in this study are epidermal polygons from *Bromus*; trichomes, point-shaped epidermal appendages from the base of grass leaves; general, needle shaped conifer phytoliths; phytoliths that are common to all species of *Pinus* and phytoliths specific to *Pinus contorta* (shore pine); astrosclereids for *Pseudotsugamenziesii* (Douglas-fir); leaf phytoliths from *Larix* and calcium oxalate sphericals associated generally with deciduous tree species (such as, *Alnus rubra* or *Acer macrophyllum*). Also included are phytoliths identified as being associated with *Agrostis*, *Festuca rubra*, *F. occidentalis*, *F. subulata*, *Digitaria* spp. Of these, no phytoliths were identified that were associated with *Pseudotsugamenziesii*, *Larix occidentalis*, *Digitaria* or calcium oxalate sphericals from deciduous trees.

Slides were systematically scanned at 400X with the Nikon eclipse E600 and as a phytolith was encountered, it was tallied. The number of phytoliths counted per level is smaller than previous studies from the NW coast; this is due to poor recovery of phytoliths. Two slides per level were prepared and the average number of phytoliths for those two slides was around 100. Most of the phytoliths were consistent with those produced by grass species with very few consistent with *Pinus*, some specific to *Pinus contorta* and some general unspecified conifer.

When this project began, it was believed that the environment was mostly forested as described by Franklin and Dyrness (1973) for coastal alluvial ecosystems. In this description deciduous trees grow on either side of a stream or river with conifer trees growing outside of that riparian zone (see Figure 5.1.). The phytolith evidence,

however, told another story. The evidence suggests that this area was mostly grassland or marsh with scattered conifer tree species (see Figure 5.2.). Table 1 shows the phytolith distribution by excavated level.

Levels one through three yielded no phytoliths. This is not surprising, the sediments from this level are indicative of an accreting sand dune with no indication of soil development except at the modern surface. It makes sense then that there would be no microscopic traces of plant life for these levels. The first traces of phytoliths showed up in level four. In this level as well as for levels five and six, phytoliths consisted of the long form type that Twiss *et al.* (1969) described as long cell general grass form (see Figure 5.3.). In level seven (see Figure 5.4.) we see the emergence consistent with the Panicoid class described by Twiss *et al.* (1969).

The Panicoid class, from the tribe *Paniceae*, has four genera that are indigenous to Oregon; *Echinochloa*, *Eriochloa*, *Panicum*, and *Paspalum*. Of these, two species are found in western Oregon: *Paspalum distichum* (knotgrass), which grows west of the Cascades in dry meadows and *Panicum capillare* (witchgrass) which typically grows throughout the entire continent. Microscopic particles of *Paniceae* occur ephemerally in levels seven, 12, 13, 17 and 18. Either one or both of these grasses could be growing in this area, but both have a C4 photosynthetic pathway (Clements *et al.* 2004). C4 grasses have an evolutionary advantage over C3 plants as long as water is a limiting factor (Fitter and Hay 2002) and this is normally not the case in the Northwest coast. For this reason the presence of this class of phytolith was unexpected as this would

make it harder to compete with C3 grasses that normally inhabit the coastal Northwest.

Perhaps the sporadic presence of this grass is a proxy indicator of periodic droughts.



Figure 5.1. Forested stream bank of the Oregon Coast Range. Franklin and Dyrness (1973) note that deciduous trees grow along the banks of rivers and streams in the Pacific Northwest.



Figure 5.2. Estuarine grassland/ marsh associated with fluvial systems.

LEVEL	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FESTUCOID					1 5	7.9	9.5	6.7	3	10	0	0.9	7.5	6.8	9.5	4.8	33. 3
CHLORIDOID					4 6	17. 8	34. 7	34. 3	24. 3	17	29. 9	29. 4	35. 8	26. 3	18. 1	26. 9	33. 3
PANICOID				2 5					0.7	1				0.8	0.9		
GEN. GRASS	10 0	10 0	10 0	7 5	3 9	41. 2	45. 3	43. 8	62. 5	59	55. 2	53. 2		48	56. 7	18. 2	50
EPI POLYGON						27. 7		12. 4		11	11. 2	10. 1	8.5	7.6	47. 6	3.8	1
TRICHOME									5.1	2							
GEN CONIFER						1	2.1	1			3.7	3.6		1.7	2	1	
PINE						2				3					0.9	9.6	
SHORE PINE						1		1	1.5			0.9			2	3.8	1.9
AGROSTIS							1.1		4.4						0.9		
RED FESCUE									1.5	2							
WESTERN FESCUE						2		1									
SUBLATA FESCUE												0.9					
LOLIUM									0.7								
N=	6	3	6	4	1 3	101	95	105	136	10 0	104	109	106	118	105	104	9

Table 5.1. Phytolith counts per excavated level. Units are in percent of total count per level. Green indicates samples from LU6, red from LU5 and black from LU3.



Figure 5.3. Generalized grass long cell phytolith.

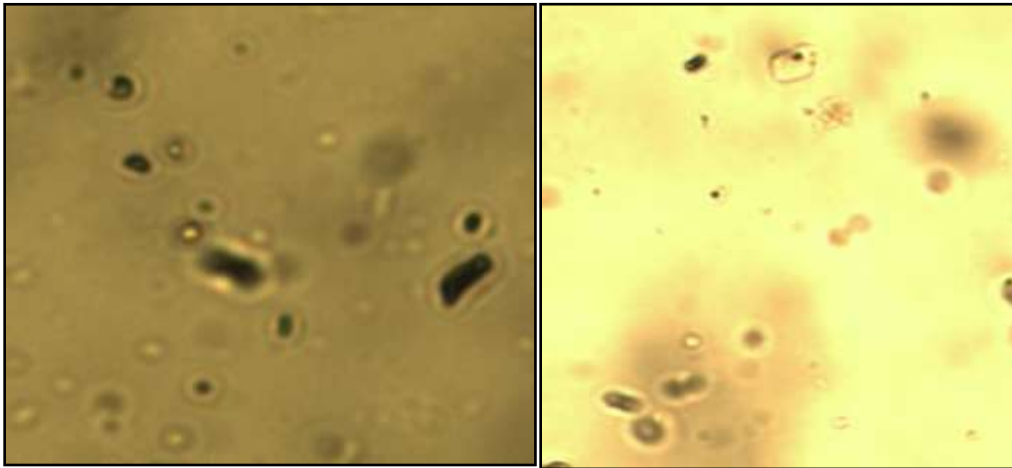


Figure 5.4. Saddle-shaped microscopic particle consistent with Panicoid phytoliths.

Starting at level eight, we see the beginning of what Twiss *et al.* (1969) describe as the Festucoid and Chloridoid class; these two classes of grass are the dominant species in the sedimentary record at this site. Only one species in the subfamily Chloridoideae is indigenous to the coastal Northwest and that is *Distichlis spicata* (saltgrass) (see Figure 5.5.).

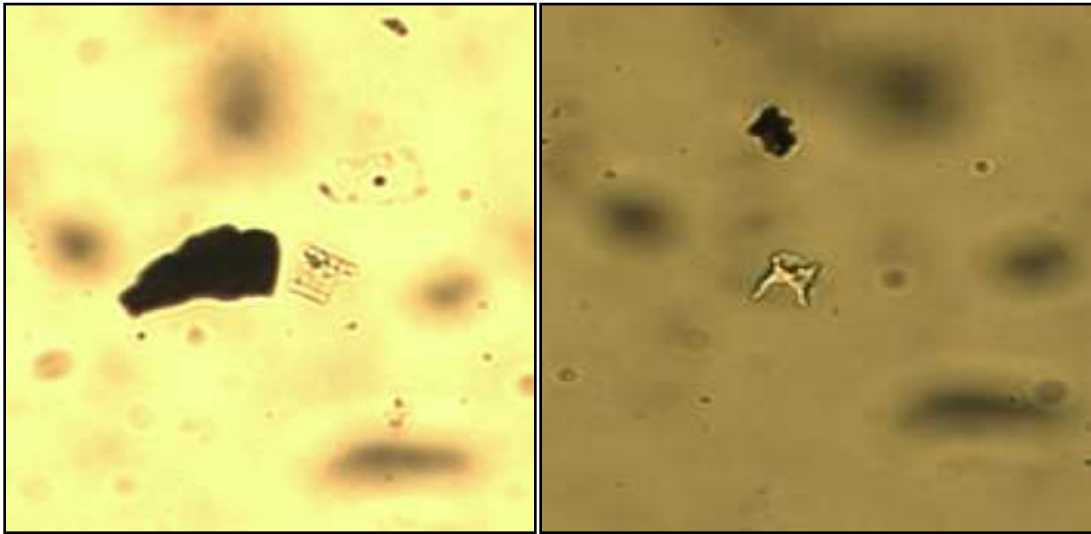


Figure 5.5. Phytolith shapes consistent with the chloridoid class.

The festucoid class has the largest number of grass species that are native to the area of study. These include: *Festuca occidentalis* (western fescue), *Festuca rubra* (red fescue) and *Festuca subulata* (bearded fescue) (see Figure 5.7.).

Distichlis spicata is a non-obligatory halophyte; this means its preference is towards salty environments, but it can also do well in non-salty conditions. It is best suited in areas that are prone to partial inundation but can survive under full inundation. It grows well in all environments along the coast, from marshes to sandy dunes. The coastal variety *Festuca rubra* var. *juncacea* grows on sand dunes, coastal meadows, headlands, and near streams (Albert 2015).

These phytolith sub-families turn out to be very good proxies for the different environments on the southern Oregon coast (figure 5.6.) gives an overview of the species found within these sub-families and the environments they inhabit.



Sub-families and their Associated Species on the Southern Oregon Coast		
Chloridoid	Saltgrass	Salt tolerant, can be inundated daily by water
		
Festucoid	Western fescue	Somewhat salt tolerant, survives being buried by sand Intolerant to being inundated by water
	Red fescue	
	Bearded fescue	
Panicoid	Knotgrass Witchgrass	C4 grasses, drought tolerant
		

Figure 5.6. Sub-families and their associated species and environments

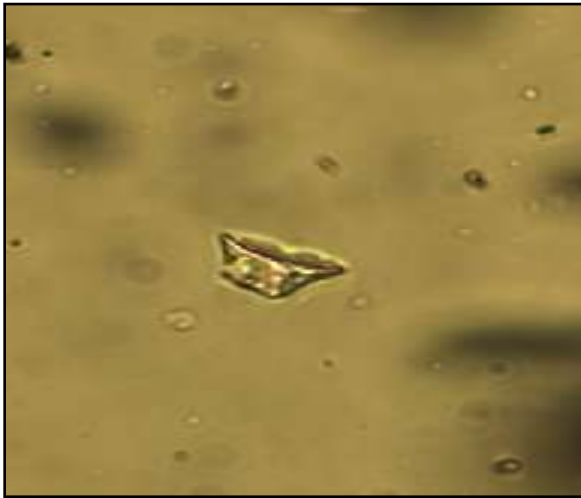


Figure 5.7. Phytolith shape consistent with Festucoid class from Twiss *et al.* 1969

More recent work by Blinnikov (2005) and McCune and Pellatt (2013) have further refined classification of plants from phytoliths in the Pacific Northwest. Not only have they defined diagnostic shapes for Northwest grasses, but also for some trees, including phytoliths that are general to all conifers and others that are common to all species of pine and ones specifically to *Pinus contorta* (shore pine), as shown in Figure 5.8. and Appendix II.

The two most dominant classes in this study are that of the chloridoid and festucoid classes comprised of the species *Distichlis spicata* and members of the genus *Festuca*, and for the purpose of this analysis all other species, that are not trees, will be considered as ancillary. Figure 5.8 shows the relationship of *Distichlis* to *Festuca* through the excavated levels and, by extension, through time.

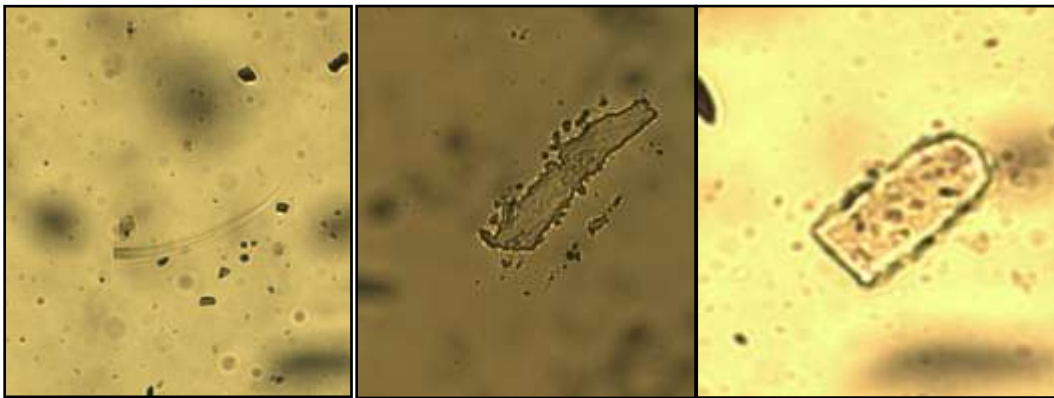


Figure 5.8. From left to right generalized conifer, common pine, and specifically *Pinus contorta* (all from Devil's Kitchen)

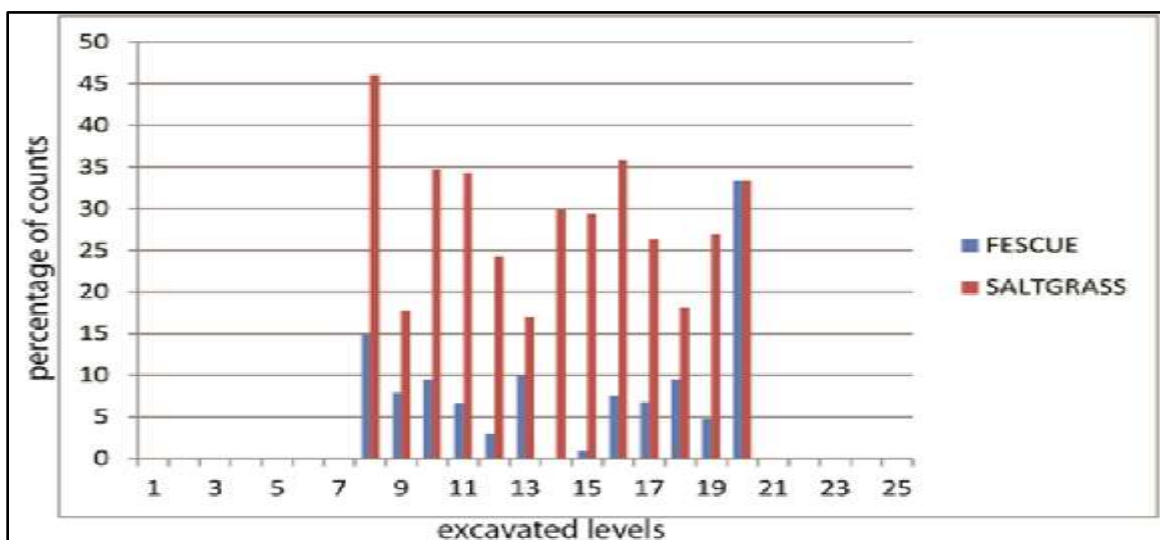


Figure 5.9. Chloridoids (*Distichlis*) vs. Festucoids (*Festuca*) through levels and time within LU5.

That the generally greater abundance of *Distichlis* (saltgrass) indicates that this taxon has a competitive advantage over *Festuca* and that this advantage is based mainly on a habitat that is periodically affected by saltwater.

Charcoal analysis

For macroscopic charcoal, 73 pieces of charcoal were identified. Of these, 61 were identified at least to the genus level; of those 61 pieces, 29 were identified to the species level. Twelve pieces of charcoal were only identifiable to the family level. From those charcoal pieces identified to the species level 26 were submitted for radiocarbon dating. All the charcoal samples belonged to the class *Coniferales* (see Table 2).

The process for identifying the wood charcoal was to compare samples from the field with microscopic slide images of known wood samples acquired from the xylarium at Oregon State University's Department of Wood Science and Engineering. The process for identifying charcoal samples is the same for identifying unknown wood samples, and that is to identify the patterns of wood cell structures within three different planes of a sample of wood or charcoal see Figure 5.10. The first section, the transverse plane cuts across the long axis of the stem of the woody plant. This is the plane where growth rings are observed. Important elements in regards to identifying species from this plane are; the size and arraignment of vessel elements and tracheids, size and location of pitch channels and the degree of diffusion or sharpness with regards to the transition on earlywood and latewood. The radial plane is perpendicular to the growth rings and passes through the center of the stem; the tangential plane is also parallel to the growth rings but does not pass through the center of the stem; in what is known as flat sawn lumber. In both of these views, the important structures for identifying the woody plant are rays and pitch channels (Hoadley 1990).

The first step was to determine which samples were derived from conifer (softwood) trees and broadleaved (hardwood) trees. This is fairly straightforward because deciduous trees have arrangements of large vessel elements that are absent in conifers. From Figure 5.11., large vessels can be seen in both the comparative collection from the xylarium and the charcoal comparative collection in contrast with the samples of conifers. Since no deciduous trees were discovered the next step was to determine the species of conifers represented by the charcoal. This becomes harder when dealing with charcoal, because the traits that help distinguish between closely related genera like *Tsuga* and *Pseudotsuga* are subtle and easily destroyed by the process of turning wood into charcoal and the degradation of organic material over time.

Pinus contorta (shore pine), however, is very different from other pines. In comparing *P. contorta* with *P. ponderosa* (ponderosa pine), a striking difference in their tangential plane is noticed, (see Figure 5.12.).

CATALOG #	SPECIES	RCYBP	LU
120	<i>Pinuscontorta</i>	1994±29	5
131	<i>Pinuscontorta</i>	1901±28	5
117	<i>Pseudotsuga</i>	2101±23	5
124	<i>Picea</i>	2093±23	5
548	<i>Pinuscontorta</i>	2087±23	5
541	<i>Pinuscontorta</i>	2503±37	5
540	<i>Picea</i>	2608±24	5
543	<i>Pinuscontorta</i>	2571±28	5
535	<i>Pseudotsuga</i>	6750±35	5
538	<i>Picea</i>	11626±51	5
407	<i>Pseudotsuga</i>	11698±51	5
545	<i>Pinuscontorta</i>	2741±26	5
551	<i>Picea</i>	4274±26	5
544	<i>Picea/Pseudotsuga</i>	11616±55	5
536	<i>Picea</i>	9333±44	5
547	<i>Pseudotsuga</i>	6739±35	5
546	<i>Picea</i>	7858±36	5
534	<i>Picea</i>	11565±37	4
549	<i>Tsuga</i>	11521±40	5
550	<i>Picea</i>	10638±42	4
542	<i>Pseudotsuga</i>	6765±35	5
552	<i>Pseudotsuga</i>	11596±37	4
553	<i>Tsuga</i>	8189±31	5
554	<i>Pseudotsuga</i>	6748±31	5

Table 5.2. Radiocarbon dates and species for charcoal recovered in Unit C.



Figure 5.10. Sections of a wood stem showing the transverse plane, the radial plane and the tangential plane. X indicates the Cross-sectional or transverse plane; R is the radial plane that bisects the diameter of the stem and T is the tangential plane.

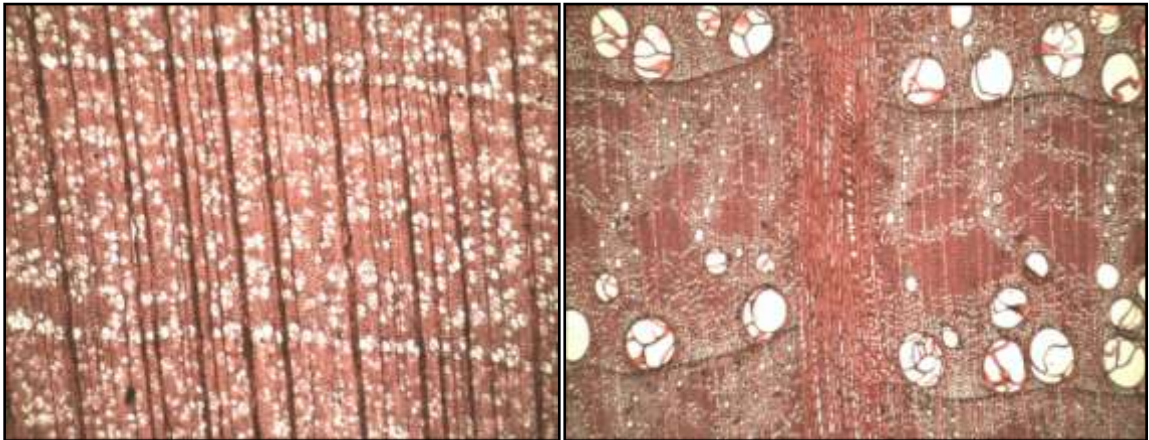


Figure 5.11. Image on the left is the transverse plane from *Arbutus menziesii* (Pacific Madrone). Image on the right is from *Quercus garryana* (Oregon white oak) both showing arrangements of large vessel elements. From Oregon State University, Department of Forestry's xylarium.



Charcoal images *Arbutus menziesii* and *Quercus garryana* on the right showing the vessel elements

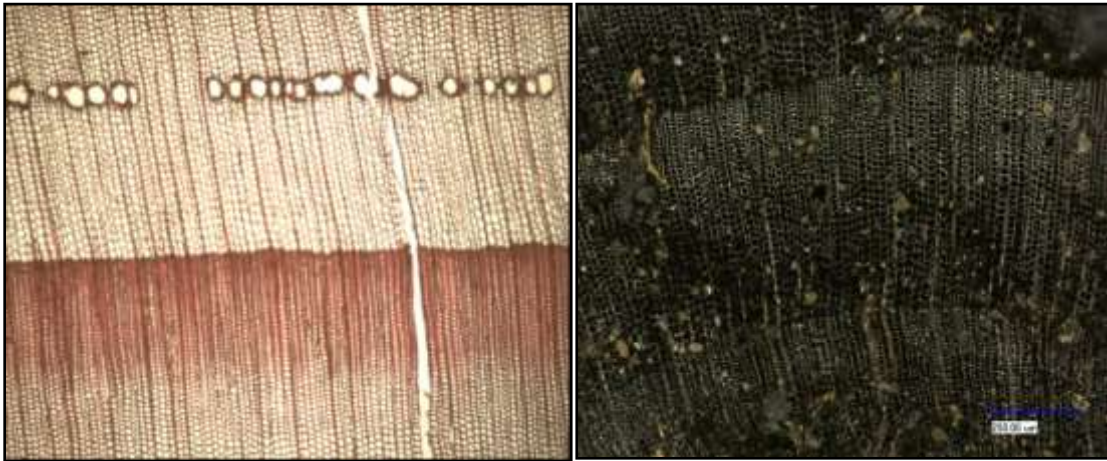


Image on left is the xylarium slide for *Picea sitchensis* and on the right charcoal for *P. sitchensis*.

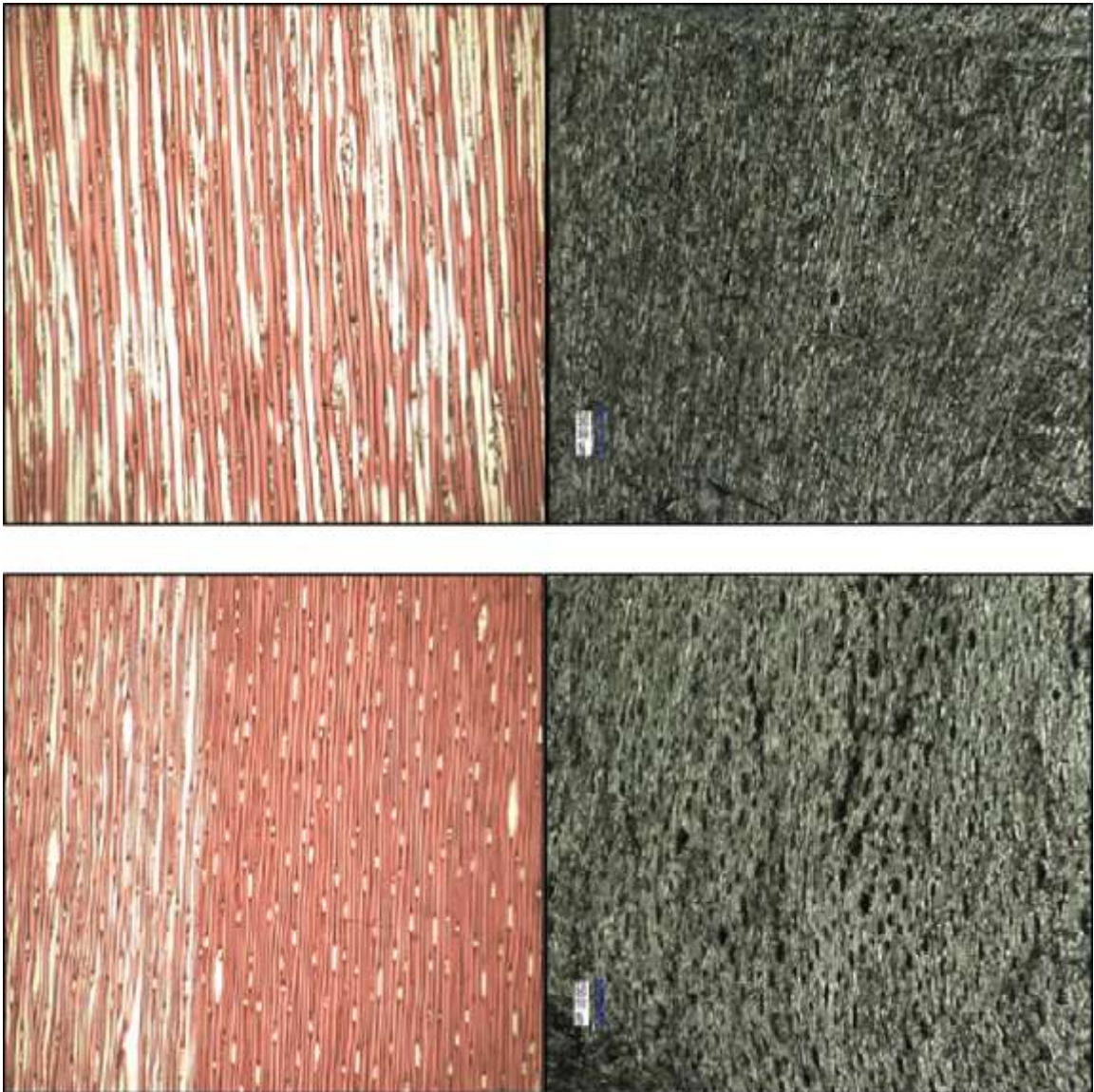


Figure 5.12. Top is the tangential plane for *Pinus ponderosa* and below is the same plane for *Pinus contorta*. Notice the numerous large single rays in *P. contorta* that are absent in the image for *P. ponderosa*.

The large numerous rays in *Pinus contorta* are unique among trees in the Pacific Northwest and their presence is a positive identification for this species. For the other species that grow in the coastal Pacific Northwest; *Picea sitchensis* (Sitka spruce), *Tsuga heterophylla* (western hemlock), *Pseudotsuga menziesii* (Douglas-fir), and *Thuja plicata* (western red-cedar); differentiation of species using charcoal mostly entails

comparing the location and arrangement of resin canals from the transverse plane, see Appendix II.

Aquatic micro-remains

Plants are not the only organism to use silica to produce intercellular structures to promote rigidity. As a result of having the same density as plant opal phytoliths, they will also be held in suspension by the higher specific gravity solution. And as importantly as the plant phytoliths, they can also tell a story about the past environmental conditions.

Starting in layer 20, the micro-botanical remains and charcoal signature in the sediments changed markedly. Phytoliths and charcoal or charred plant material are absent from the samples. In their stead are sponge spicules (see Figure 5.13. and 5.14.). Fresh water sponge spicules and other aquatic micro-remains from levels 20 to 25 indicate that this area was part of a stream channel. In Figure 3.3 it is noted that level 20 in LU5 is at the bottom of an erosional channel which surrounds LU4 and bordering LU3 so it makes sense that aquatic micro-organisms would be present.

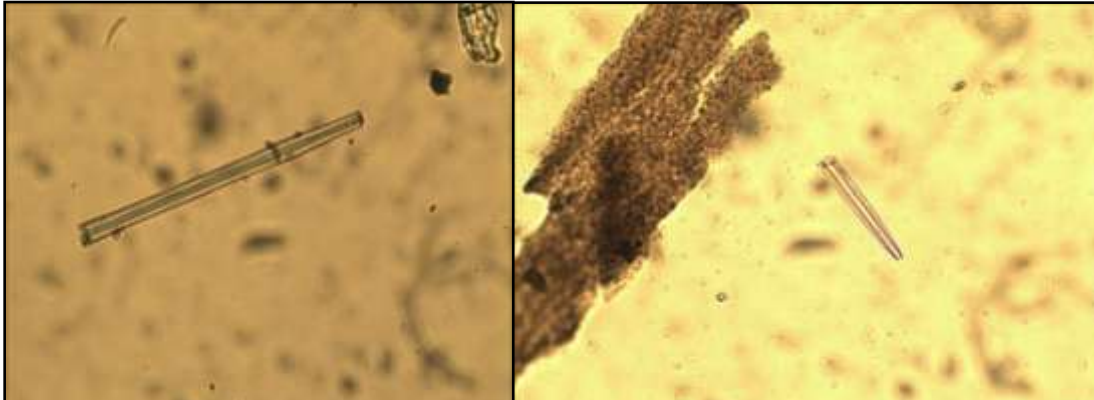


Figure 5.13. Examples of sponge spicules found in sediments from levels 20 to 25.



Figure 5.14. Image of Freshwater sponge from the Pacific Northwest, genus *Spongilla*, from sitkanature.org.

Summary

In summary, the following observations are made about the plant communities at the Devil's Kitchen site through time.

LU1 is marine terrace uplift and was not sampled in this study as it was not present in the west wall where samples were taken from. LU 2 and LU 3 are silt and clay that lacked phytoliths but contained aquatic micro-organisms and dates prior to $11,596 \pm 37$ RYBP. A potential reason that these lithostratigraphic units could have lacked phytoliths was that these sediments were deposited in an aquatic environment, or that this deposition happened rapidly, not allowing time for plants to grow. LU4 was not sampled for phytoliths because sediments from it were not present in the west wall and its significance was unknown at the time of sampling; it dates to between $11,596 \pm 37$ and $10,638 \pm 35$ RYBP. LU5 are alluvial deposits of silt and clay it ranges in age from 4274 ± 26 to $1,901 \pm 28$ RYBP. Phytoliths suggest that at this time this area was grassland consisting of fescues and salt grass. LU6 is sand dune and no phytoliths were recovered from this lithostratigraphic unit in any significant amount.

Moving forward in time from this point the area is primarily grassland consisting of fescues (*Festuca rubra*, *F. occidentalis*, *F. subulata*), and saltgrass (*Distichlis spicata*). The tree root cast we excavated through in the center of Unit, (see Figure 5.15.) was identified as *Pseudotsuga*. It is believed that four samples from this tree were sampled from different layers. The first from the sample at the bottom of the unit (catalog no. 554) is 6748 ± 37 ; the others from different levels are: (catalog no. 542) 6765 ± 35 ,

(catalog no.547) 6739 ± 35 and (catalog no. 535) 6750 ± 35 (all dates are in radiocarbon years before present). This tree is in growth position in LU4, without further evidence the most parsimonious explanation is that prior to around 6750 radiocarbons years ago this area was a Douglas-fir/ western hemlock forest that was situated 3 to 10 kilometers from the shore of the Pacific Ocean. At this time this tree died, and most likely the rest of the forest in a fire. Due to sea level rise the environmental conditions changed enough that the forest was not able to reestablish itself and the area became coastal grassland. The presence of this root system most likely aided the sediments of LU4 to not be eroded in the event that eroded the sediments surrounding it.



Figure 5.15. Arrow indicates location of charcoal rich remains of a tree identified as belonging to the genus *Pseudotsuga*.

Chapter 6: Conclusions: Interpreting the Environment at Devil's Kitchen Through Time.

Proximity to the Ocean and Plate Tectonics as drivers of Environments

The driving factor of which species of plant appears in which landscape along the Oregon coast is primarily that landscape's spatial relationship to the ocean (Franklin and Dyrness 1973; Albert 2015). There are two very dynamic forces that have and are still shaping that spatial relationship: one is sea level rise and the second is tectonic uplift and co-seismic subduction; Figures 6.1. and 6.2. demonstrates this relationship. During the last glacial maximum (LGM) between ~26 to 19 thousand years ago, the climate on the coast of Oregon and Northern California was not much different from today. Heusser (1960) states that winter time temperatures were 3 to 5 degrees Celsius colder, and precipitation was somewhat less than today. But sea levels were approximately 130 meters lower than at present (Clark *et al.* 2014). Lowering sea level has the effect of moving the littoral zone, the zone affected by oceanic tides, further to the west exposing landscapes that are presently underwater. As continental ice sheets melted, sea levels rose obtaining modern levels at circa 6,000 years ago (Ames and Maschner 1999; Clark *et al.* 2014). Figure 6.1. models the consequences this would have for plant species composition as an area becomes closer to the coastal margin. This is because it appears that proximity and elevation from the ocean are the key factors whether an area is a forest, grassland, marsh, or sand dune. Normally it is difficult to change the plant community compositions that are established in an area and

conditions are stable (Mittelbach 2012). When disturbances happen the plants that are in the area are the ones most able to seed the disturbed area. Some plants even are evolutionarily adapted to periodic disturbances. An example of this is *Pinus contorta* colloquially as shore pine and lodgepole pine. Its cones will only open after a fire, the fire then rids the area of plants that have been competing with the pine and leaving only the protected pine seeds to replant the area. The reason it is hard to replace entirely plant communities is because plants are able to exist in a range of habitats (Mittelbach 2012), the Douglas-fir/ hemlock forest from LU4 was probably surviving at the bottom range of its salt tolerance before dying and replaced by more salt tolerant grasses.

Devil's Kitchen sits on the southern end of a piece of land that is being tectonically uplifted. It is wedge shaped with the northern part uplifting faster than the southern section, which has the effect of displacing Crooked Creek successively southward (Curteman 2015). When levels 14 and 15 were the occupational surface, sea levels were at or near modern levels (Clark *et al.* 2014), and this area was most likely a salt marsh or estuary. I would estimate this to be between two to three thousand radiocarbon years ago.

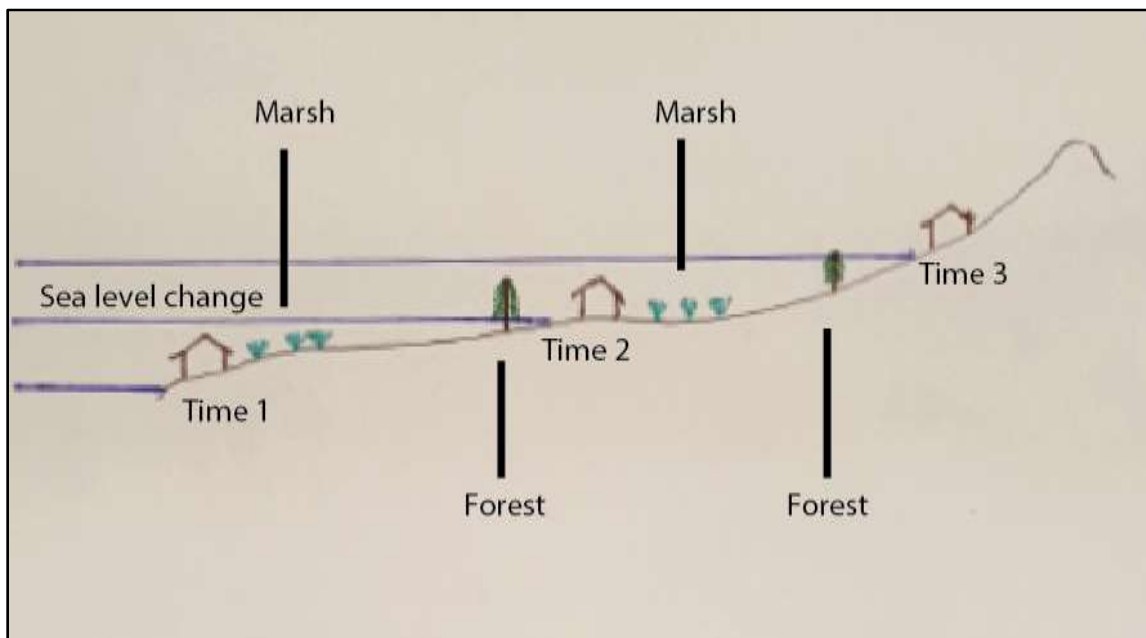


Figure 6.1. Plant species composition change as sea levels rise. In this scenario time 1 is near the last glacial maximum when sea levels were much lower than today. As sea level rise due to melting glaciers, becoming time two and sequentially time 3, productive estuarine environments and the human occupants that exploited these environments moved with it. In the process, former terrestrial deposits and occupations are now water.

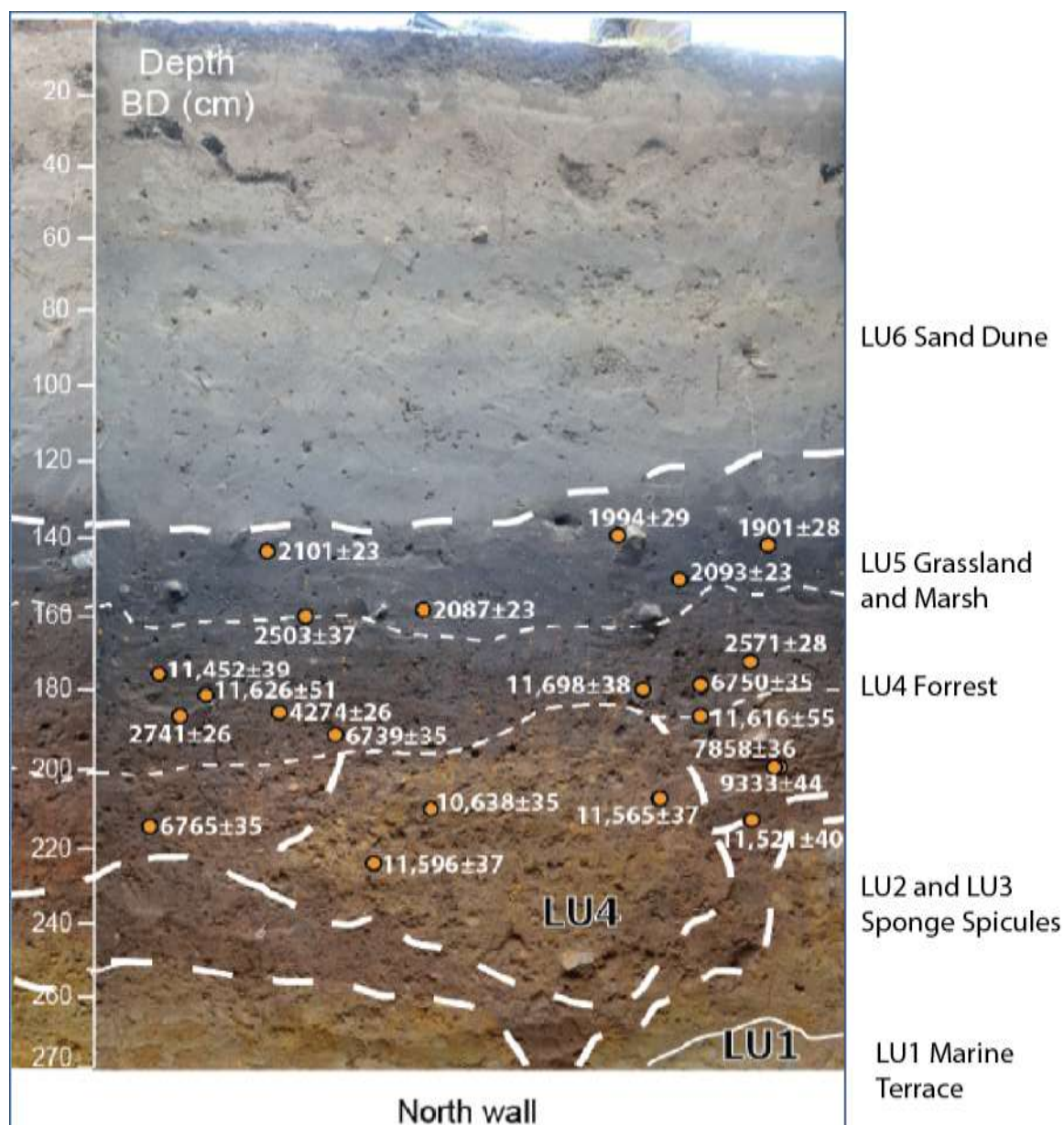


Figure 6.2. Summary of environments based on microscopic and macroscopic data

It is difficult to ascertain what was going on in this landscape during the late Pleistocene because sediments from LU4 (which is the intact package of sediments that date to this time) were not included in this study. LU2 and LU3 contain no phytoliths that were recovered in this study, instead what was found were aquatic organisms. The increase in

sand in the sediments suggests that at this time this area was subject to higher energy erosional events instead of lower energy depositional events.

Transitioning into the Holocene, one aspect that is clear is that at or about 6,750 RCYBP, there is a tree growing in the middle of the unit (Figure 5.14). This tree was identified as either being *Pseudotsugamenziesii* (Douglas-fir) or *Tsugaheterophylla* (western hemlock). Both species more generally grow in forests, as opposed to singularly, in the open, so at this time it is considered that this area was forested. The presence of this tree probably aided in the preservation of LU4 as an intact unit. This particular tree's demise is unknown but it did burn at some point and the forest that was most likely there did not return probably because the ocean was now close to its present location and the site's environment shifted to that of an estuary or salt marsh. This is because, as sea level rises, the kinetic energy of streams falling towards the ocean decreases, and it is even possible that at high tide a stream can back up and overflow its banks. This situation best explains the sedimentation seen in LU5 and the dominance of saltgrass in the landscape. Since then, this landscape has apparently remained stable in terms of its plant species composition. Frequent flooding would prevent trees from being able to establish themselves but there is other evidence that this was not the only factor in perpetuating this stability of plant species composition.

Looking back at Figure 5.8 it is seen that fescue was never a dominant genus, but from levels 20 to 16 it was still a key component of the landscape. Then in level 15, fescue is almost nonexistent and disappears entirely in level 14, returning again in levels 13

through 8. The period of time roughly represented by levels 14 and 15 is 2503 ± 37 to 2087 ± 23 RCYBP. The dominant species throughout most of the history of this site has been saltgrass.

Distichlis spicata (saltgrass) is a non-obligatory halophyte, which means it tolerates growing in salty environments but salt is not required for it to grow. Although this genus is found throughout North and South America only the species of *D. spicata* is seen in Oregon (Albert 2015). This plant is found throughout Oregon in estuarine salt marshes, interior alkali flats and sandy lake beaches. This leads to the interpretation that this was an estuary until tectonic uplift pushed Crooked Creek further to the south and the sand dune that now caps the site appears sometime around 1,900 years ago.

The Role of Fire in Determining Species Composition

Proximity to the ocean and tectonic action has a large impact on what environments are expressed in an area but they are not the only dynamic forces here. In the western United States fire is important in maintaining environments. Species have evolved with the presence of fire and some, including *Pinus contorta* (shore pine) cannot reproduce without fire, as their cones will not open and release the seeds within them until they reach a specific temperature.

The dominant micro-remains in the slides from LU5 were the presence of microscopic charcoal or ash (Figure 6.3.). These remains and the presence of charcoal indicate that

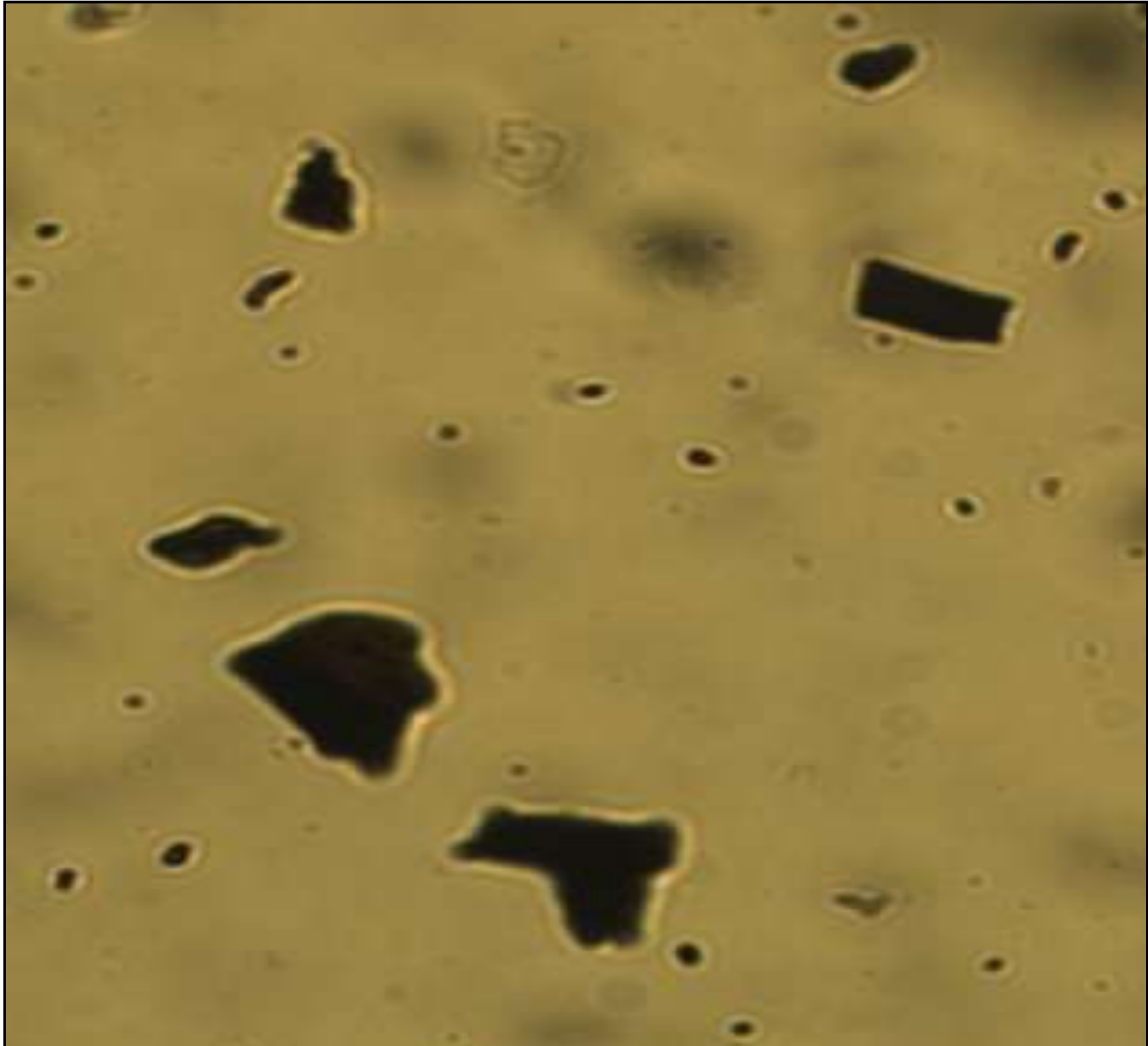


Figure 6.3. Arrows indicate microscopic particles identified as charcoal

Fire was a factor in this site's environment. As stated earlier, fire is part of the natural environment in the American west, but how often does that occur especially in the Pacific Northwest in general and the southern Oregon coast in particular?

Natural fires are caused by lightning strikes. Keeley (2002) researched natural fire occurrences in coastal California and found that natural fires occur about every one hundred years. This rarity can be attributable to a few factors. One is that during the

winter the coast is mostly too wet for a fire to propagate. The other is that lightning storms during the drier summer months are also rare on the coast (Keeley 2002).

Another factor has to do with oceanic conditions. During the summer months stronger along shore winds come from the North, driving what is known as Ekman transport.

This is a phenomenon where wind pushes ocean water along with it, as sea level tries to maintain a constant; lower, colder, water moves to the surface (Ortiz *et al.* 1997). This cold water, when it comes in contact with the warmer air creates fog. This fog also has the effect of reducing the likelihood of fires during the summer months (Pisias *et al.* 2001).

The question is: Do the micro-remains of charcoal represent the natural fire cycle, or are there other explanations? Also, what does the presence of macroscopic charcoal mean when the phytolith evidence suggests very few trees being present?

If fires were as infrequent as Keeley notes, what then would cause the evidence for more frequent fires at this coastal site? The amount of charcoal recovered seems to be more than the phytolith evidence would suggest could occur there naturally. The alternative interpretation is that all the charcoal recovered from LU5 is the result of human activity. This conclusion is derived from the phytolith data which indicate that this area was a marshy grass land, and from the nature of the sediments in LU5 that show no indications of trees growing here in this time period.

Figure 6.4. compares the distribution of fescue to saltgrass with the artifact distribution and recovered charcoal. What is interesting in this plot is that artifact density peaks in levels 14 and 15 when fescue disappears from the phytolith record and the sedimentation is completely dominated with saltgrass. This suggests that during this time the area was daily inundated by tidal forces, in other words, an estuary. The conclusion that the data in figure 6.4. points towards is that humans will extensively exploit environments that have the potential to deliver the most resources. In a situation where there is a dynamic landscape like coastal Oregon, the position, within that landscape, of highly productive environments like estuaries are going to move. Conceptualizing this, imagine a small encampment of hunter-gatherers along a resource rich patch on the coast. As sea levels rise this encampment is moved further east, at the same time as tectonic action lifts individual blocks of land resulting in the location of

estuaries moving north or south, our imaginary encampment will move with it.

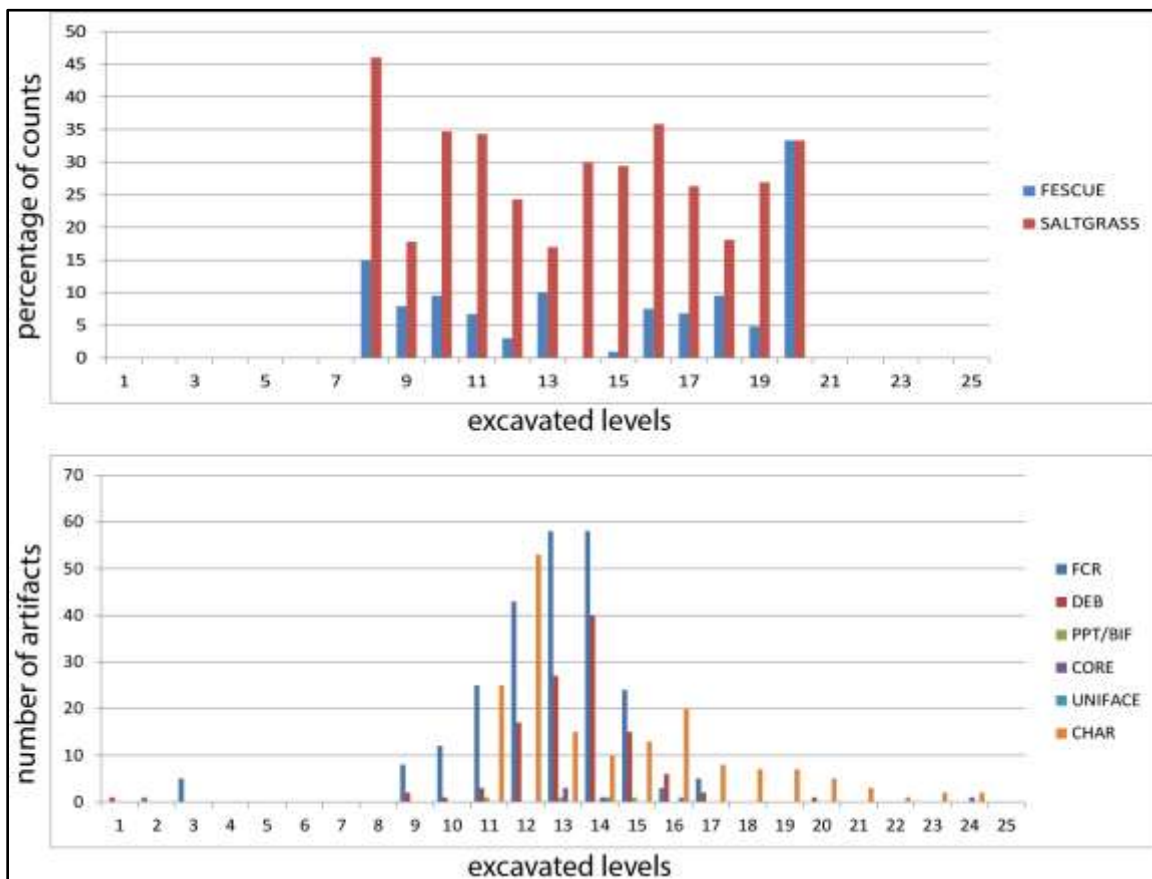


Figure 6.4. Comparison of phytolith counts for fescue and saltgrass with the artifact counts for each excavated level. FCR is fire cracked rock, DEB is debitage, PPT/BIF is projectile point/ biface, CORE is a rock that served as the base material for the production of stone tools, UNIFACE, is a stone tool with one finished edge, and CHAR stands for charcoal.

Estuaries are landscapes that provide the most resources for hunter gatherers to exploit and so it is not surprising that at this time the artifact assemblage peaks. In this model the charcoal peaks earlier than the FCR or debitage. It is the author's interpretation that this is more due to the tidal influences and the nature of charcoal preservation in an estuarine environment than a reflection of human economic activity.

Devil's Kitchen in a Regional Context

Devil's Kitchen, diachronically speaking, the site appears to have been occupied intermittently for brief durations over a long period of time; the site also shows us different periods that may be synchronically related to the larger patterns of Northwest Coast prehistory as well. Kenneth Ames has divided the Holocene on the Pacific Northwest coast into four broad categories (Ames and Maschner 1999). These periods are: Archaic (11,000 to 5,700 RCYBP), early Pacific (5,700 to 3500 RCYBP), middle Pacific (3,500 to 1,700 RCYBP) and late Pacific (1,700 RCYBP to 175 calendar years ago). Artifacts in Devil Kitchen's LU4 date to the terminal Pleistocene and it is widely understood that Native Americans at this time are mobile hunter-gatherers (Ames and Maschner 1999). An archaic form of a hunter-gatherer society implies a broad spectrum of resources exploited (Dillehay 2000: 31). Dillehay also states that, in South America it appears that even the earliest coastal sites only demonstrate what would be considered an archaic lifestyle exploiting a wide variety of resources (Dillehay 2000: 32). In this sense it can be theorized that from the initial colonization of North America, for coastal populations, a generalized hunter-gatherer economy was the norm. This also demonstrates that the densest population at this time to be along the coast (Fladmark 1979).

With population centers on the coast, they would have been roughly 5 to 7 kilometers west of where Devil's Kitchen is located in relation to the coastline when LU4 was at the surface, as much as $11,596 \pm 37$ radiocarbon years ago. Even though, as stated earlier,

forest ecosystems had very few resources available as food for human consumption, there were other reasons to exploit forest resources. One ethnographic example comes from the ethnobotany of the Coquille Indians (Fluharty *et al.* 2010). In this example Douglas-fir boughs are soaked in water and used to purify houses after funerals and washing people who have handled individuals who have died (Fluharty *et al.* 2010: 61). An activity such as collecting fresh Douglas-fir boughs would be consistent with the very ephemeral, inland activity attraction evidence expressed by the artifact evidence in LU4.

As sea levels rose, population moves inland not just to prevent from being underwater, but to stay close to sources of food. Sea levels neared their approximate modern day levels just about after 6,000 years ago (Clark *et al.* 2014). LU5 is representative of this time, as the population centers move inland because of rising sea levels, and get closer to inhabiting parts of the landscape associated with historic village sites, the artifact density at Devil's Kitchen increases (Figure 6.4.) until tectonic uplift moves Crooked Creek to the south. Without the eroding effect from the creek, sand was allowed to accumulate burying the site.

The time frame for the aggregation of LU5 corresponds with Ames and Maschner's (1999) early and middle Pacific periods. It is during the early Pacific period that hunter-gatherers in the Pacific Northwest start to organize themselves into household domestic units. It is unclear when people here first started organizing themselves this way, but excavations on Haida Gwaii (Queen Charlotte Islands) British Columbia, Canada can shed some light on the issue. This site, which is currently experiencing a phenomenon known

as isostatic rebound is where the earth's crust that has been depressed downward by the weight of continental sized glaciers rebound upwards slowly after the weight of the ice is removed. It's noted that this geologic process is not occurring on the Oregon coast but the practical implication, in terms of coastal archaeological sites, is that the timeline cultural development is not exactly known at this point. As new sites are evaluated, in this case British Columbia, the timeline of the household domestic unit it pushed back earlier into the early Pacific period (Kenneth Ames, personal communication). It's no doubt very possible that as new sites are uncovered offshore of Oregon's coast the same pattern of pushing back the time frame of cultural development will emerge.

How is this applicable for interpreting Devil's Kitchen? 35CS5 is a historic village site on the Bandon spit located on what is now Bullard's Beach State Park. The artifact assemblage at Devil's Kitchen, consisting mostly of fire cracked rock and debitage from tool manufacturing with few projectile points and point bases. The lack of diversity in tool forms indicate that this was not a generalized occupation but instead a work area that supported the village site nearby (Ammerman and Feldman 1974; Binford 1980; Bettinger 2009: 82). When the site was buried by the sand dune the activity that supported the village at 35CS5 didn't end, it just moved to a location that was similar to the one found at the Devil's Kitchen site when it was occupied. It would be highly likely then, to find a site upstream on Crooked Creek that is on the surface or shallowly buried.

The opposite is also possibly true as well. With lower sea levels and a potential village site where the coast line was at the terminal Pleistocene and into the early Holocene the same pattern should be expressed in sediments along the now inundated channel of Crooked Creek.

The conclusions of this thesis demonstrate that, in the hunt for early sites on the Oregon coast, using phytolith and charcoal analysis can aid in finding landscapes that were the most desirable for human use and occupy. It is seen here at Devil's Kitchen, when the site was far inland from the ocean due to falling sea levels during the Pleistocene it was mostly forested and that a human presence was small and ephemeral that could be easily missed outside of large scale excavations. In contrast, when the site becomes closer to the ocean due to sea level rise after the continental glaciers melt, it is closer to population centers, and environmentally, one that is more useful for human purposes. In this case the human evidence at this site becomes very dense.

Returning to R. Lee Lyman's four theories on the existence of bluff sites in Oregon's archaeological record, this study demonstrates that the answer, for Devil's Kitchen, is that it is a multiple component site. It was visited infrequently and ephemerally when it was forested prior to around 6700 radiocarbon years ago, and it was extensively exploited, but probably not occupied when it was a saltgrass estuary around 3000 to 2000 radiocarbon years ago.



Figure 6.5. Unit C at Devil's Kitchen State Park during the Final week of excavation.

Standing on the bluff at Devi's Kitchen and looking west towards the ocean (Figure 6.5.)

it would be hard to imagine that 3000 years ago this landscape was functionally very different, that it was more like the Bandon Marsh pictured in Figure 6.6. As stated at the beginning of this thesis, humans are natural beings tied to their environment. Analyzing artifact assemblages without the knowledge of the environmental conditions that they were created in can lead to mistaken evaluations. Adding a paleobotanical aspect to an archaeological investigation will not answer all the questions that may come up in an investigation, but it can put the people being studied into the environmental framework they lived in.



Figure 6.6. Bandon Marsh Natural Wildlife Refuge.

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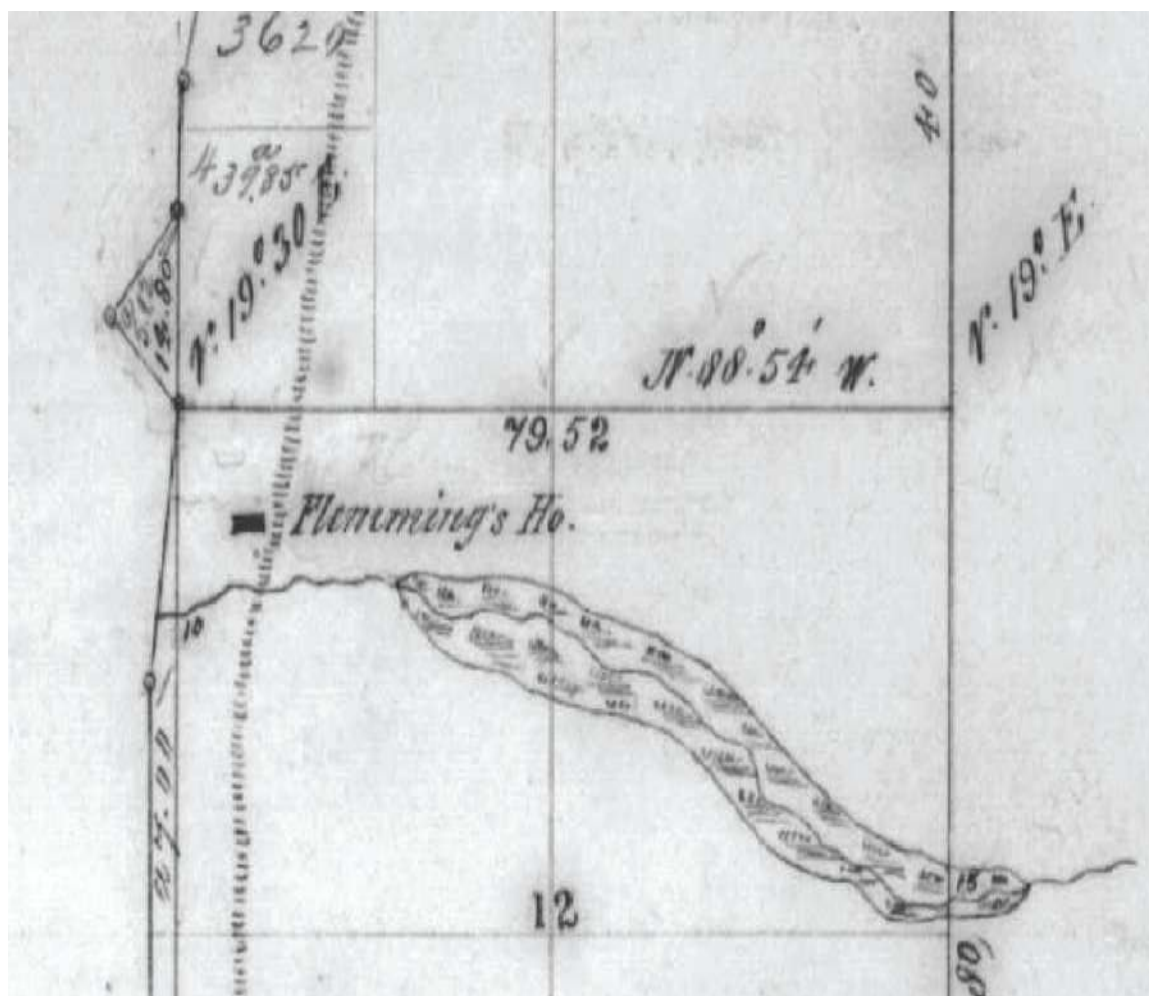
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Appendix I
Maps of the area surrounding Devil's Kitchen



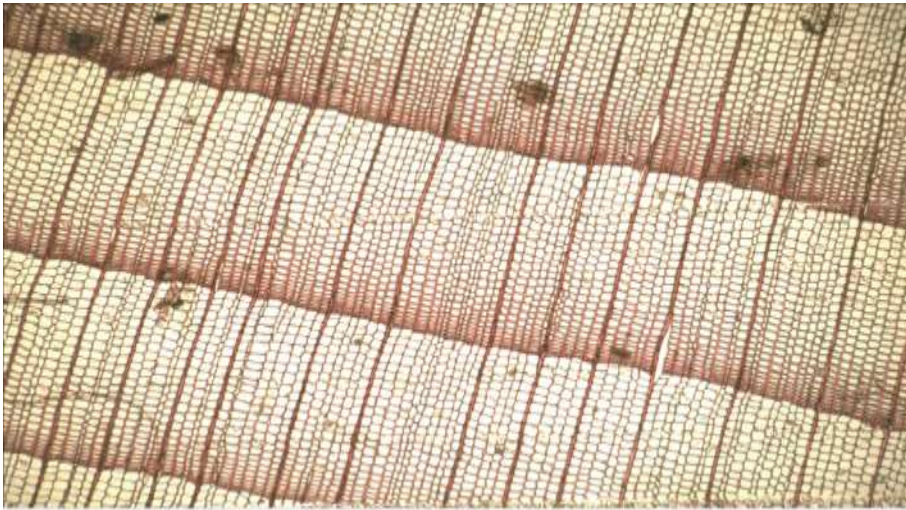
Government Land office Map of Township 29 South, Range 15 West, section 12, 1857 showing the Fleming Homestead just north of Crooked Creek and just northwest of the parking lot in the current Devil's Kitchen State Park.

Figure I.II.

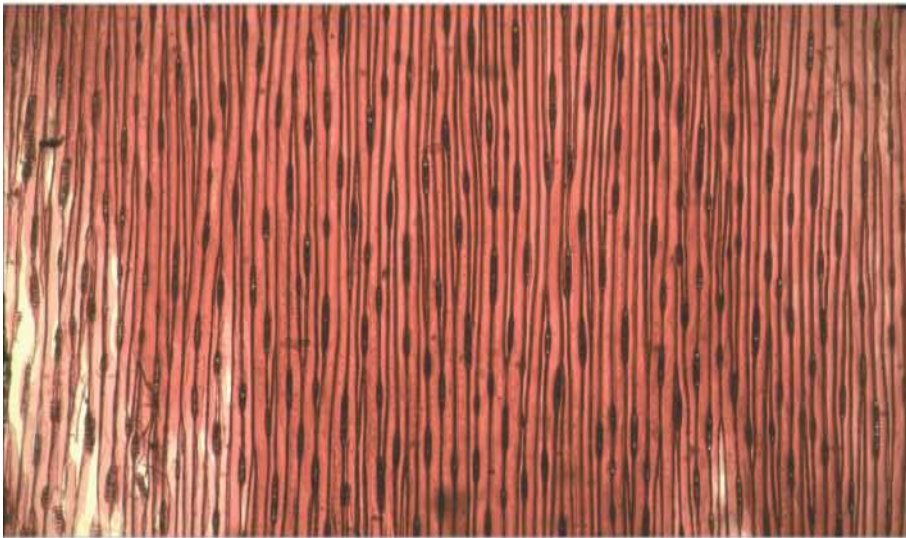


Figure I.III. Nautical chart showing the area around Devil's Kitchen, red line indicates the position of the coast at the last glacial maximum

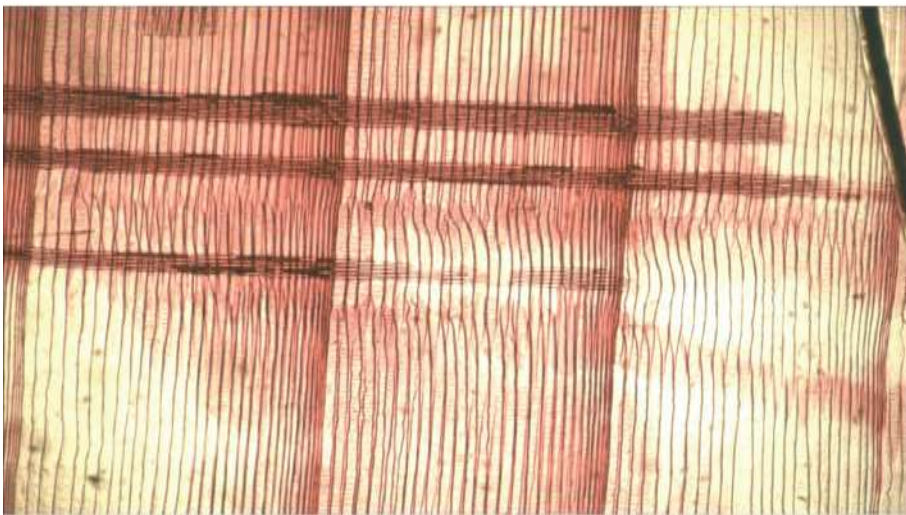
Appendix II
Wood and Charcoal comparative collection



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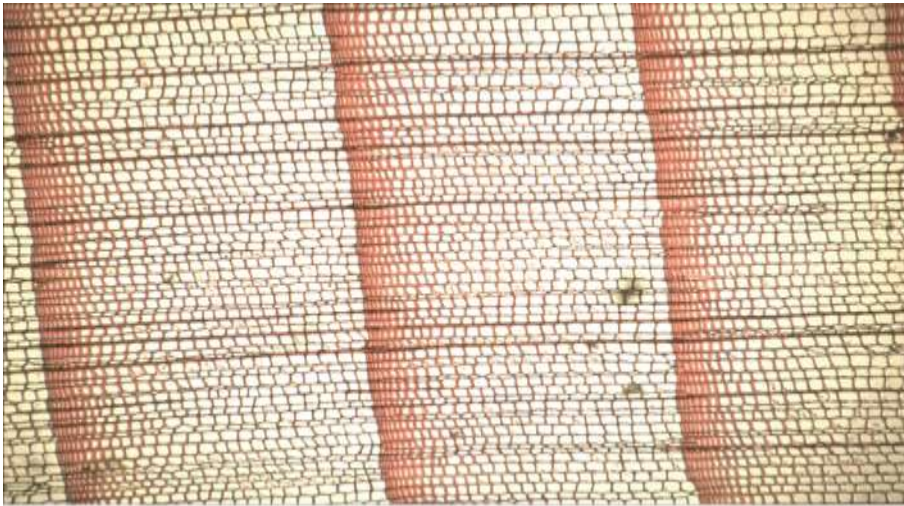


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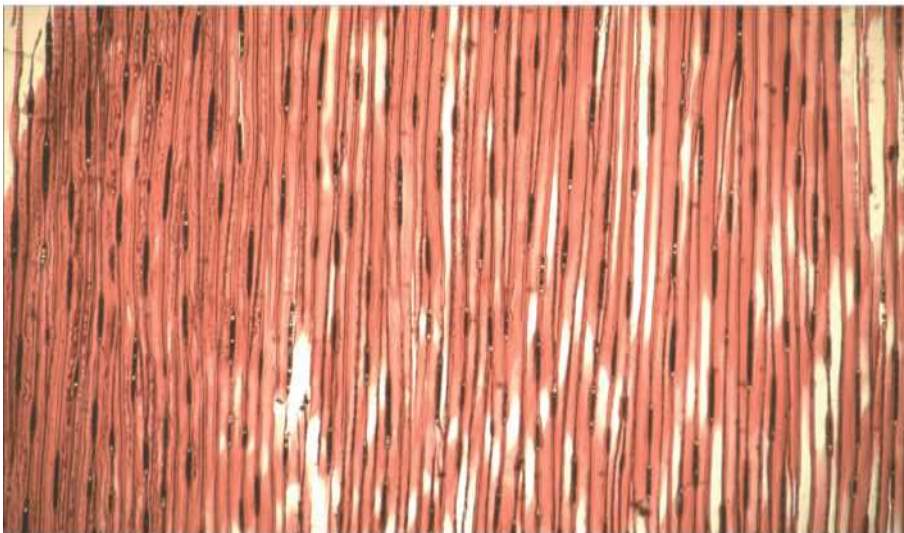


Radial

Figure II.I. *Abies amabilis* magnification 40X



Transverse



Tangential



Radial

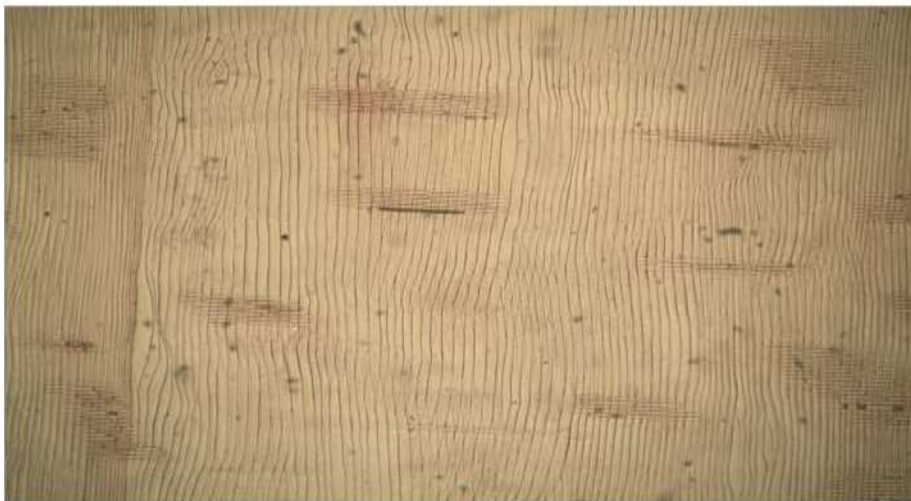
Figure II.II. *Abies grandis* magnification 40X



Transverse

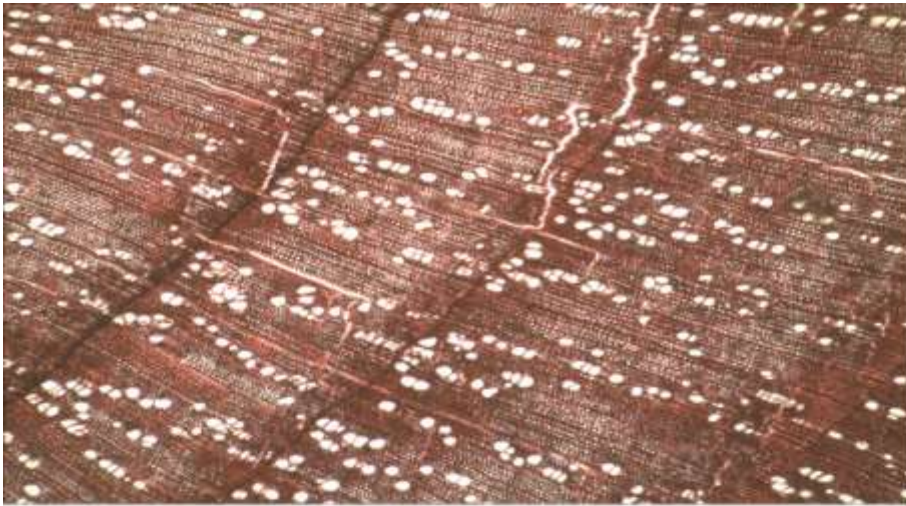


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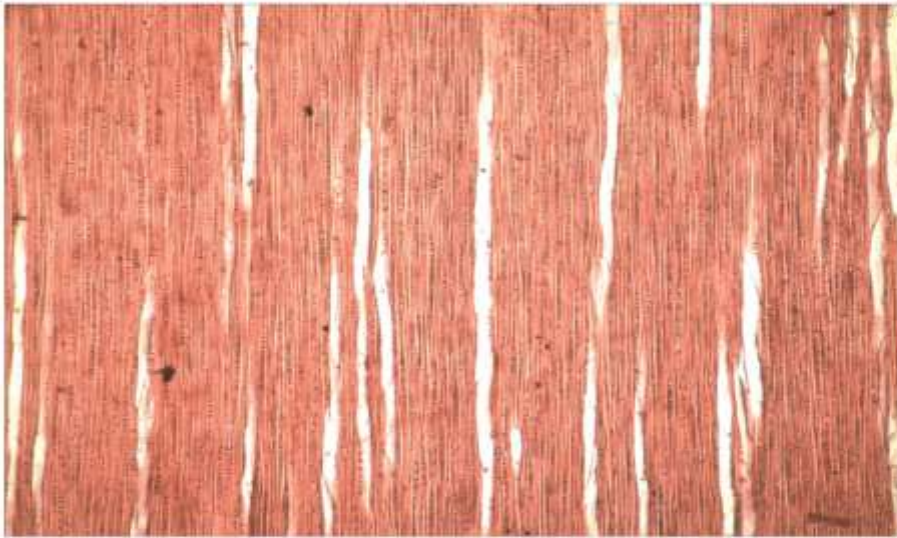


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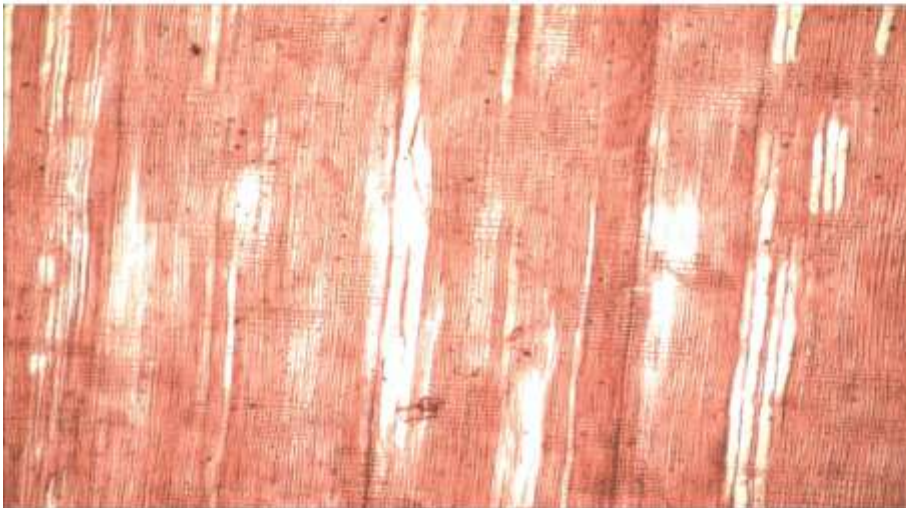
Figure II.III. *Abies magnifica* magnification 40X



Transverse

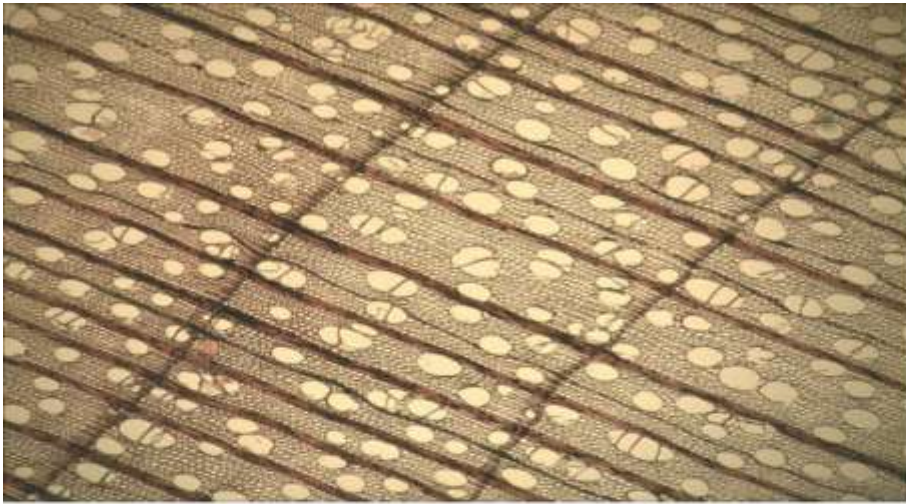


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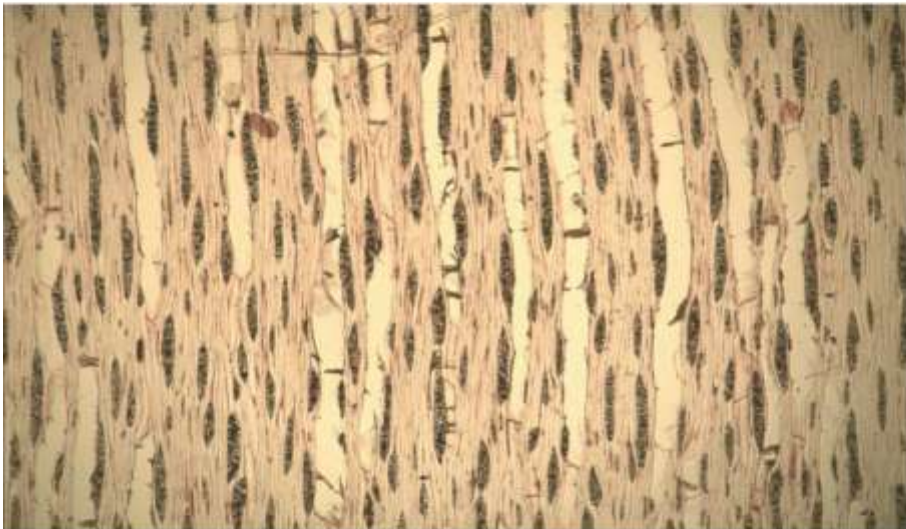


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Figure II.IV. *Acer circinatum* magnification 40X



Transverse

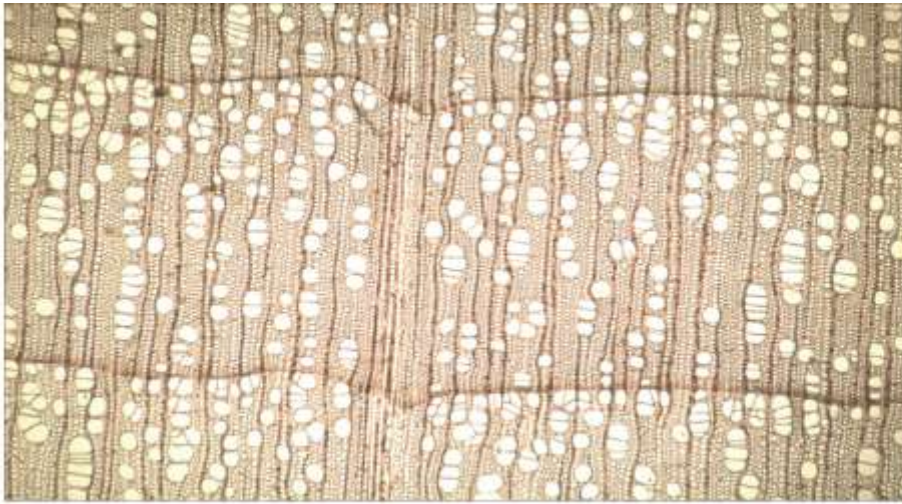


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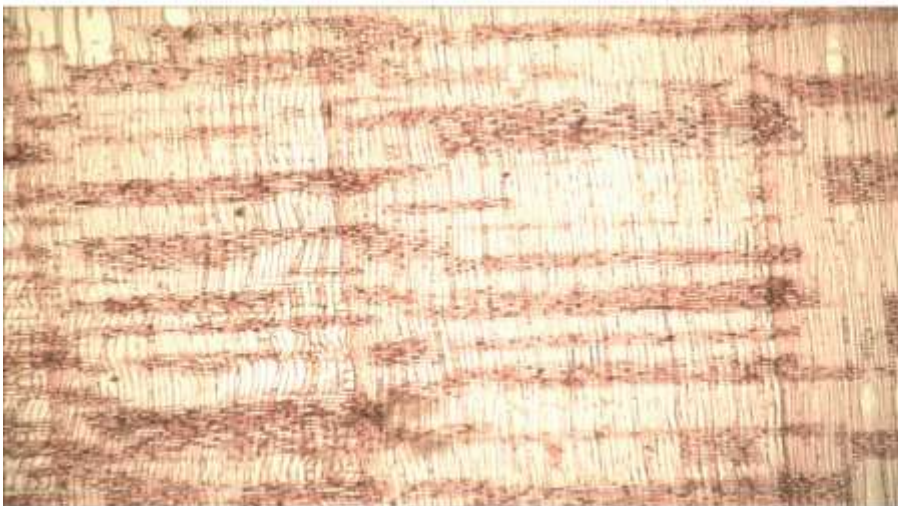
Figure II.V. *Acer macrophyllum* magnification 40X



Transverse

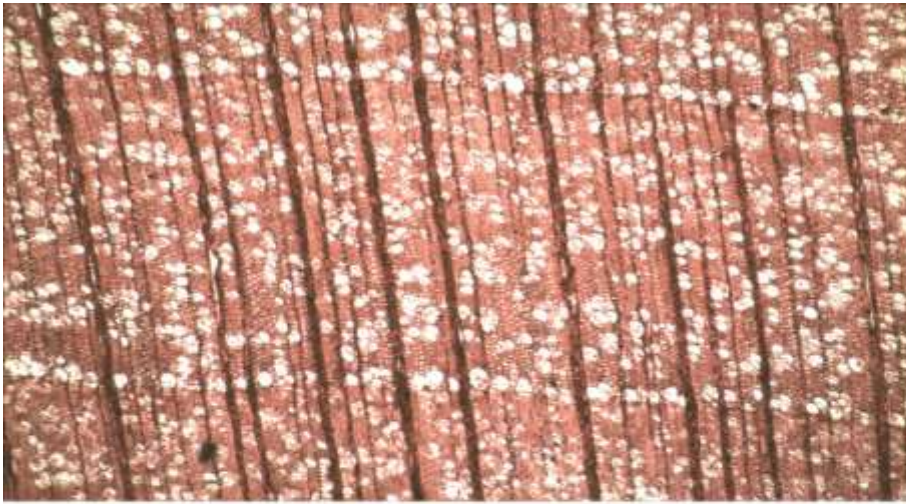


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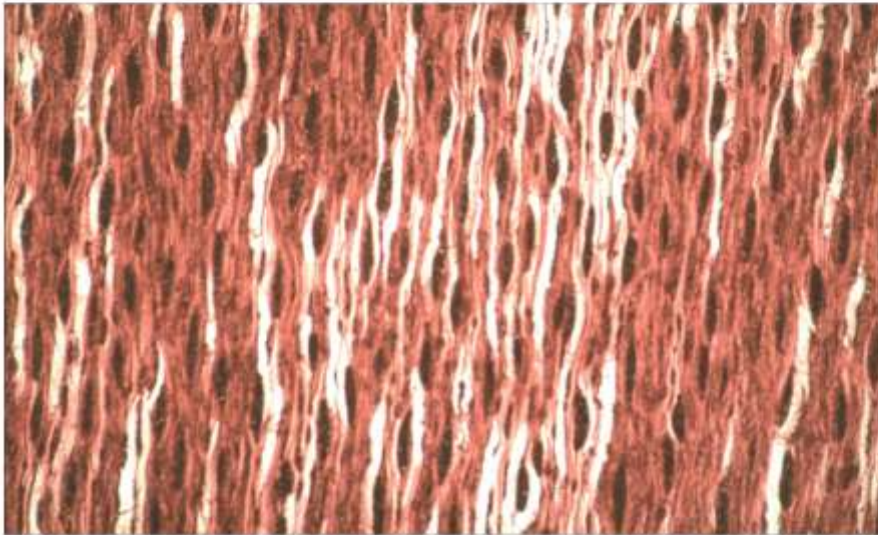


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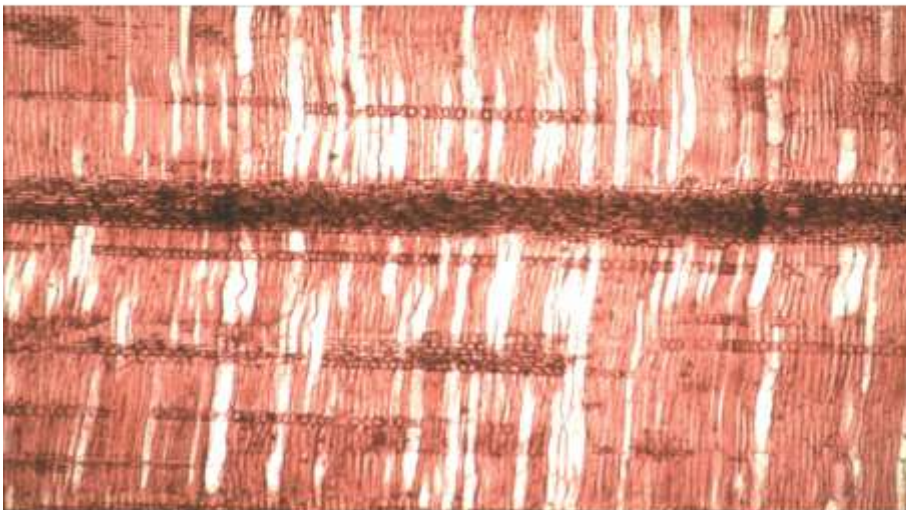
Figure II.VI. *Alnus rubra* magnification 40X



Transverse

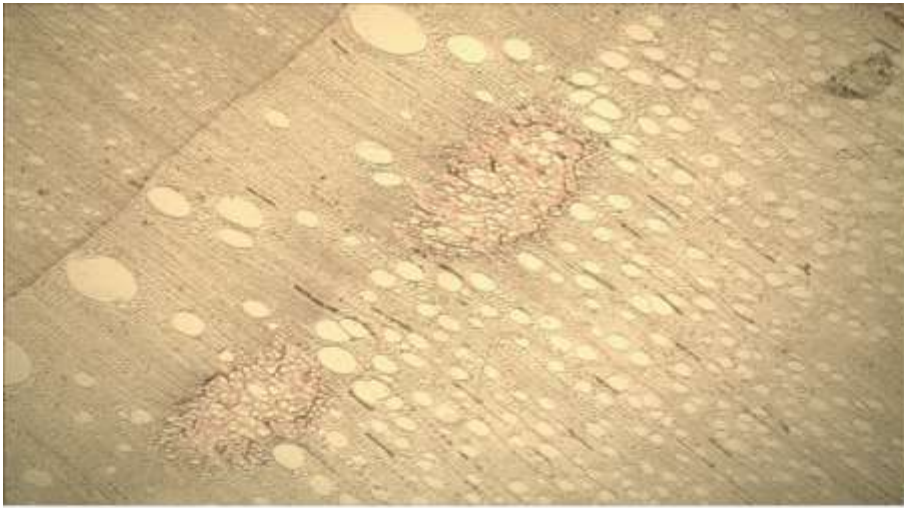


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Figure II.VII. *Arbutus menziesii* magnification 40X



Transverse



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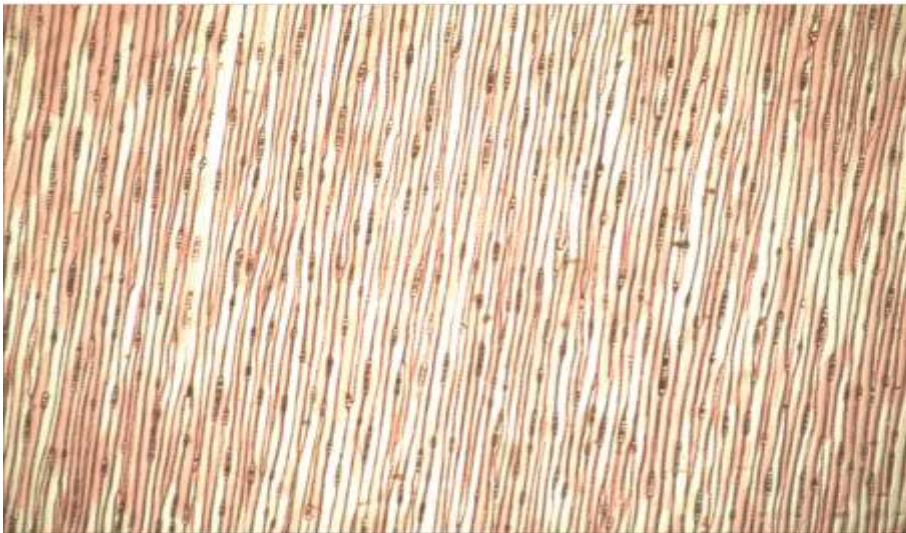


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Figure II.VIII. *Castanopsis chrysophylla* magification 40X



Transverse



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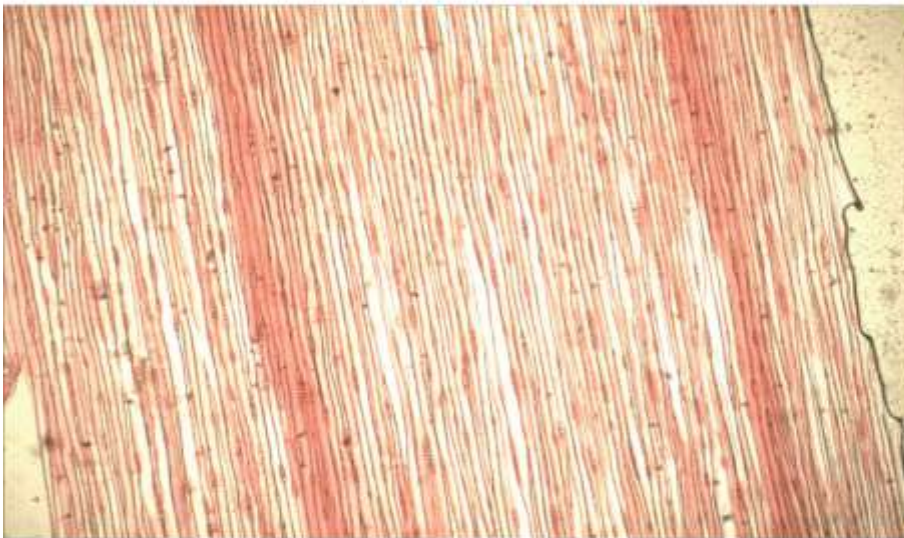


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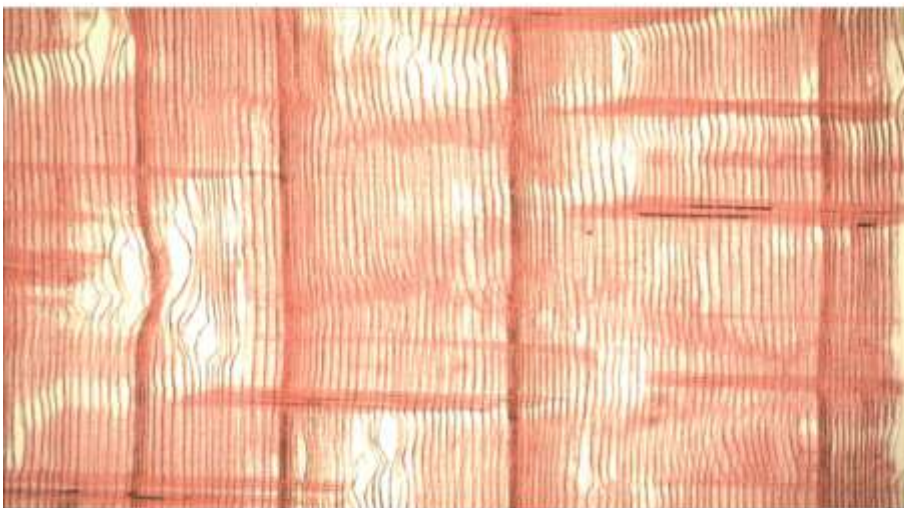
Figure II.IX. *Chamaecyparis lawsonia* magnification 40X



Transverse



Tangential

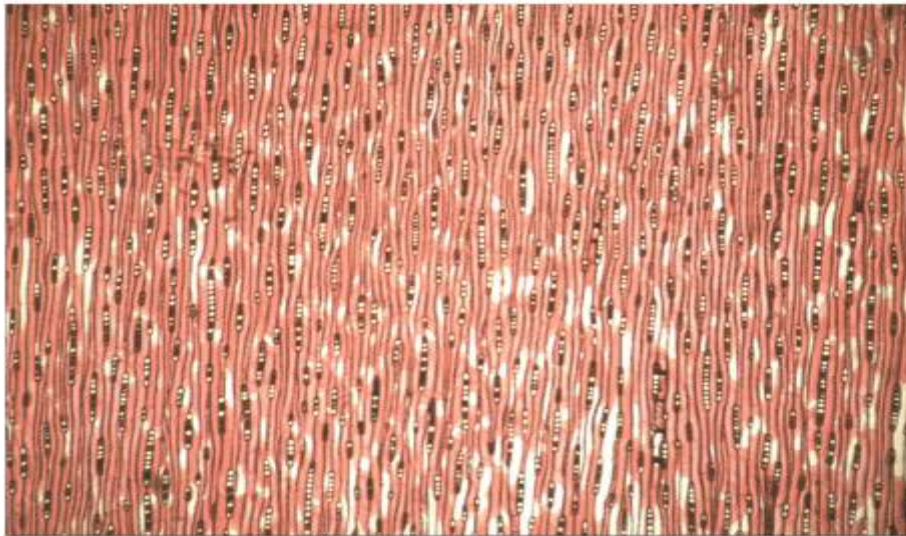


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Figure II.X. *Chamaecyparis nootkatensis* magnification 40X



Transverse

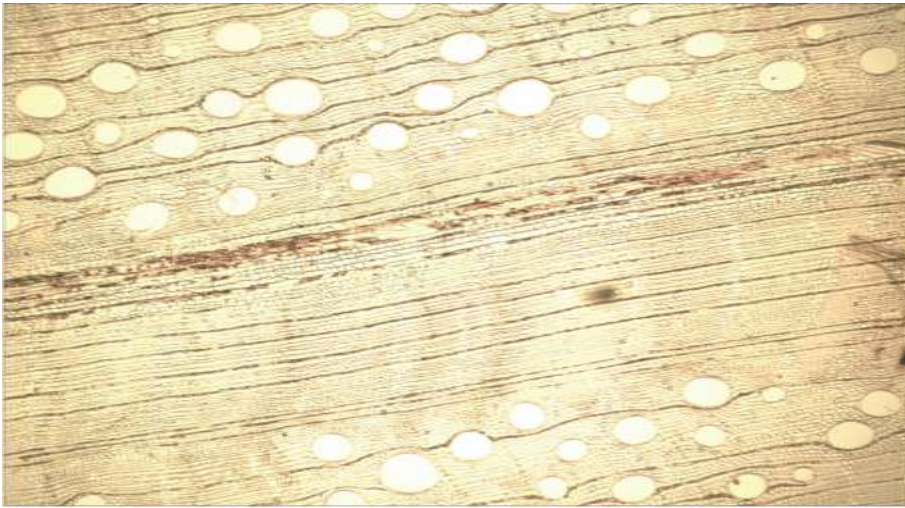


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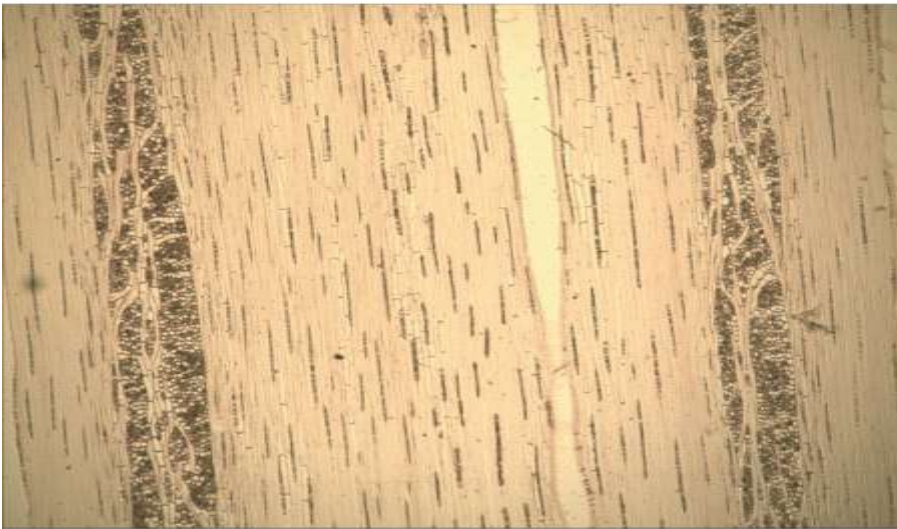


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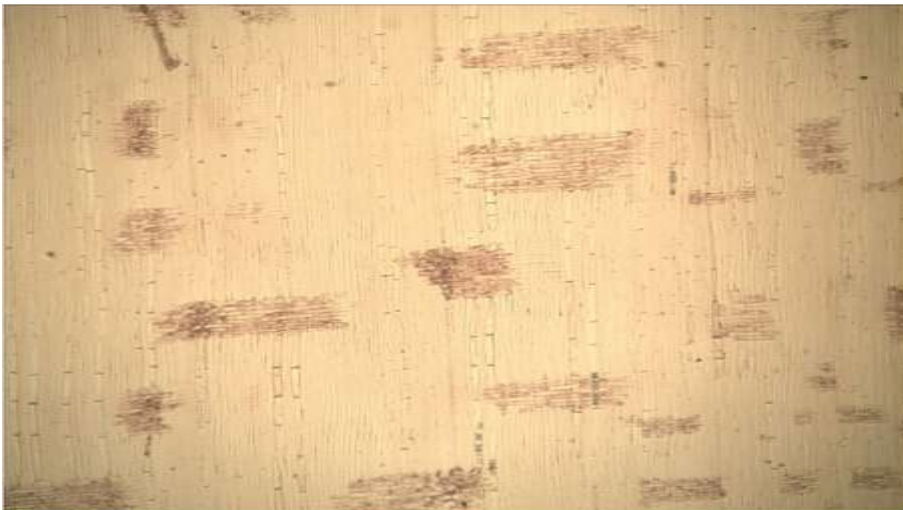
Figure II.XI. *Lidocedrus decurans* magnification 40X



Transverse

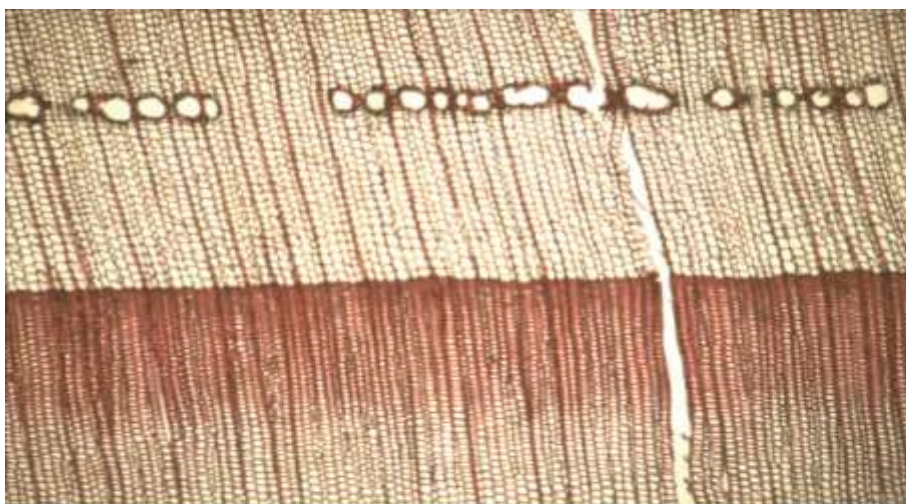


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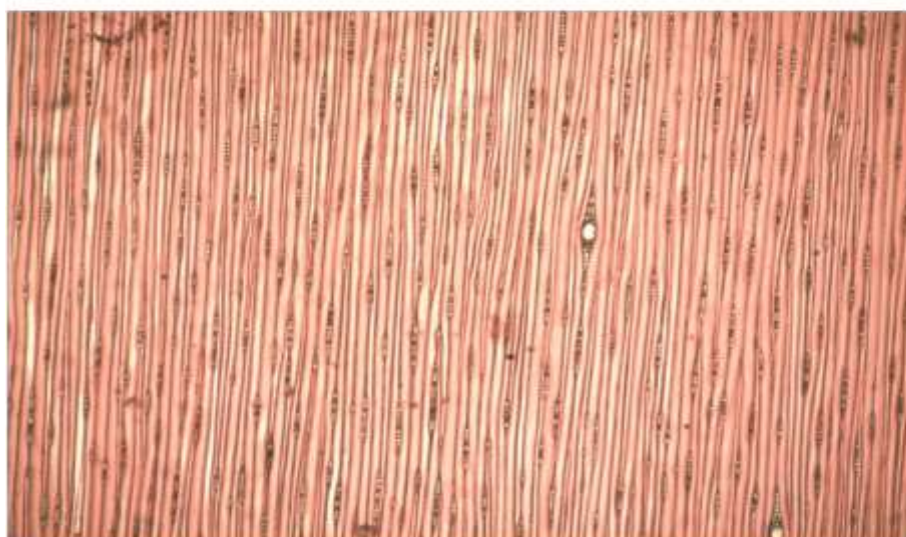


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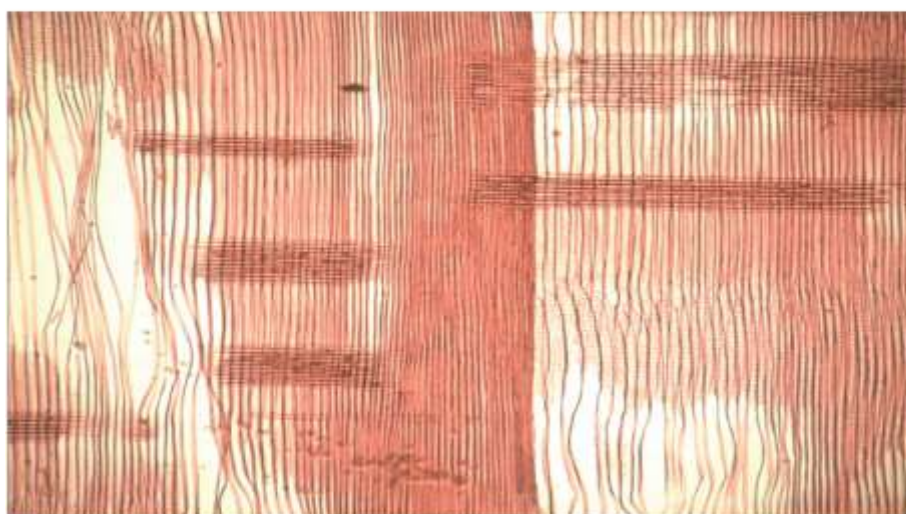
Figure II.XII. *Lithocarpus densiflorus* 40X



Transverse

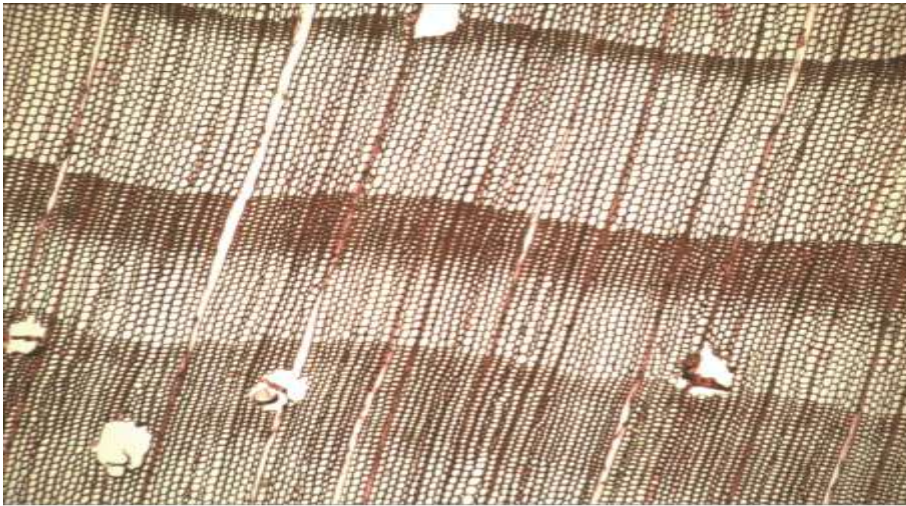


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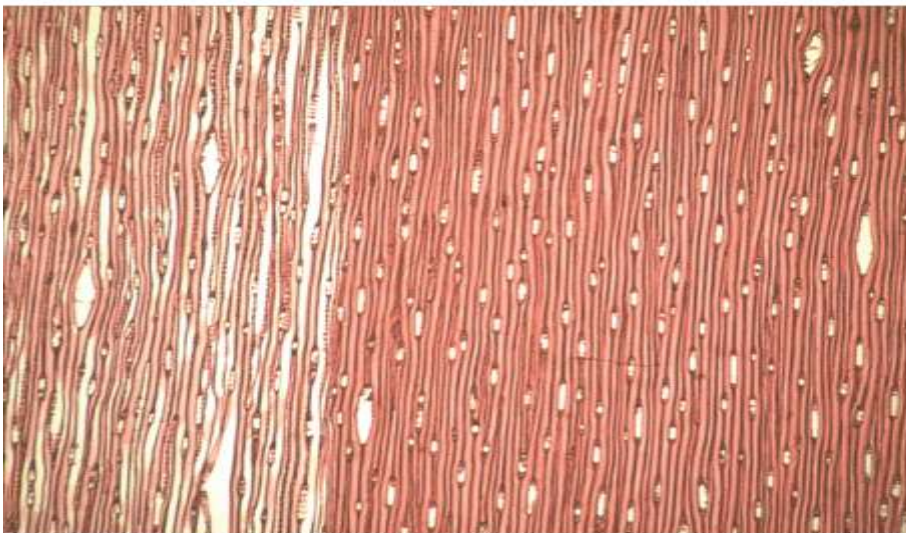


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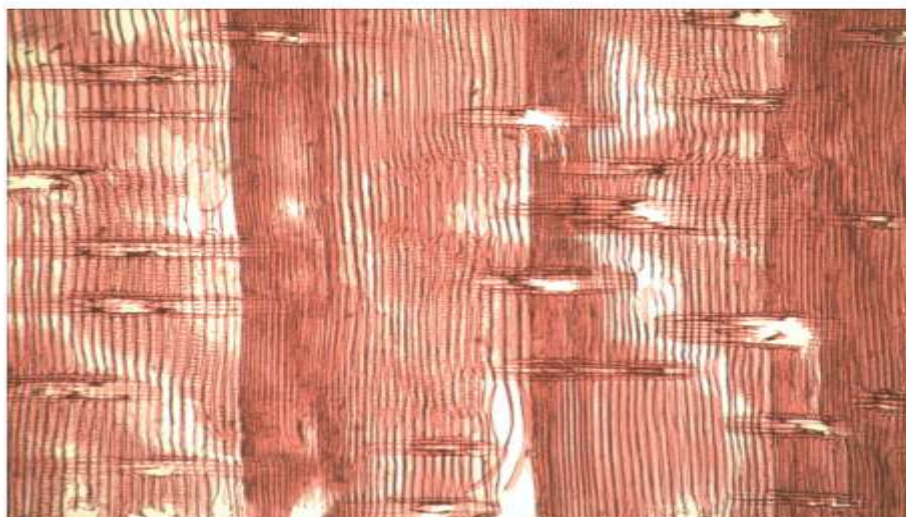
Figure II.XIII. *Picea sitchensis* magnification 40X



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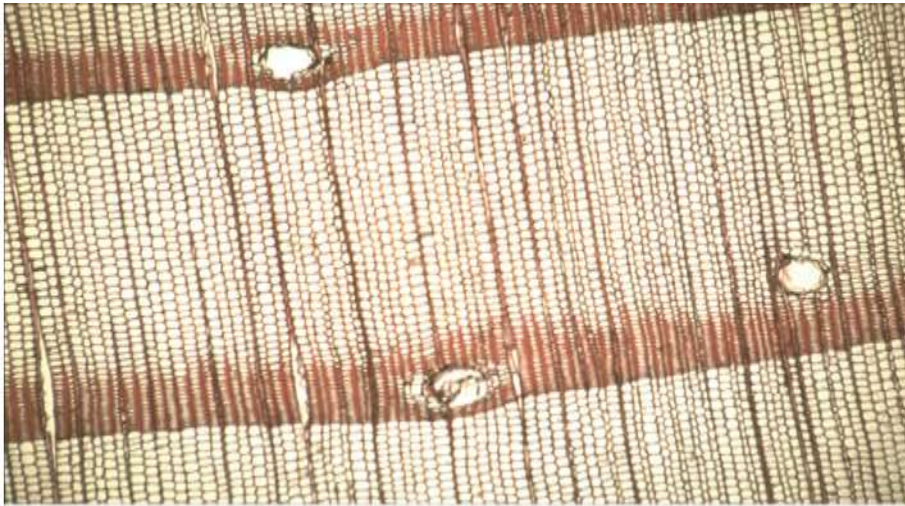


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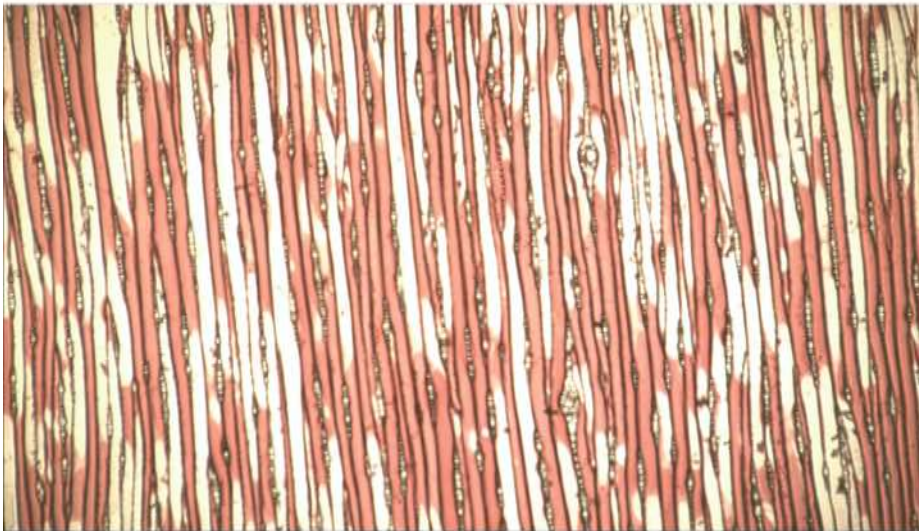


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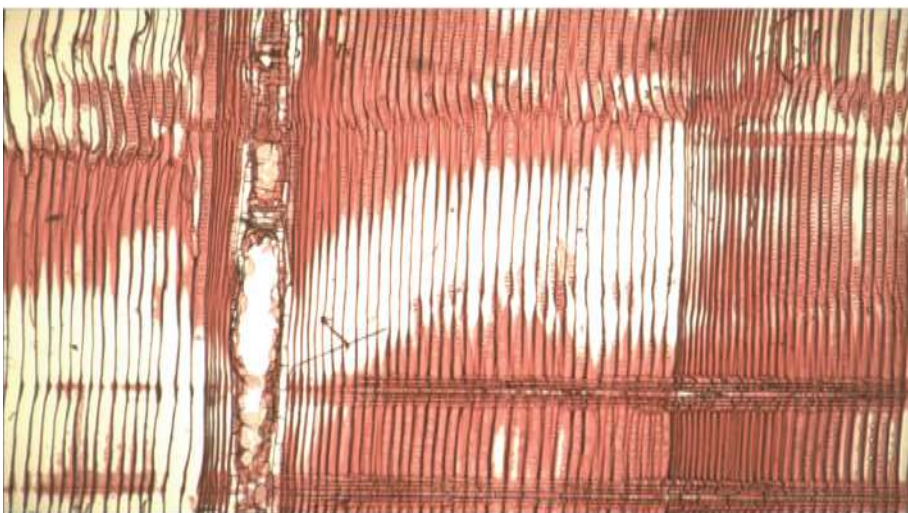
Figure II.XIV. *Pinus contorta* magnification 40X



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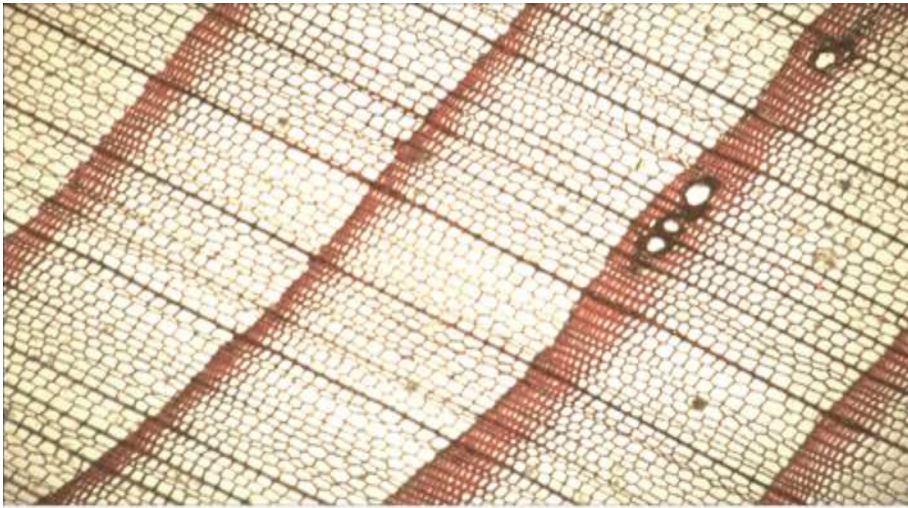


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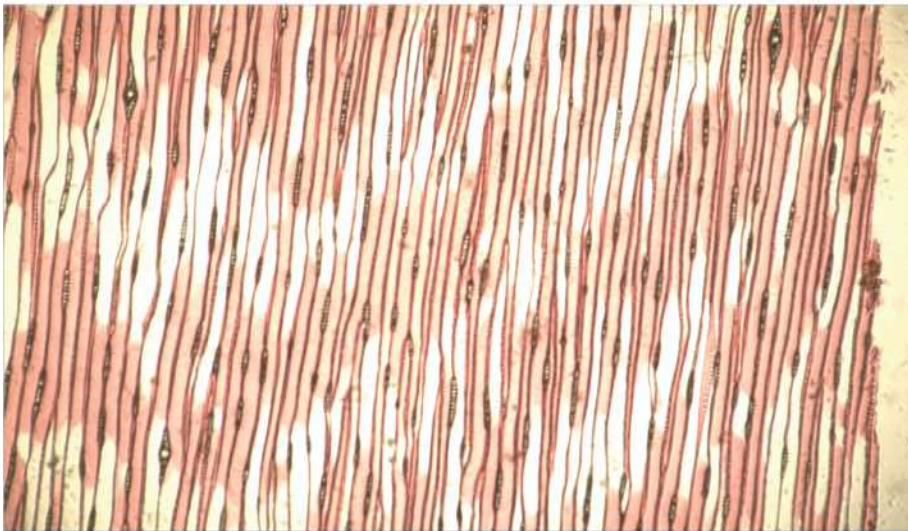


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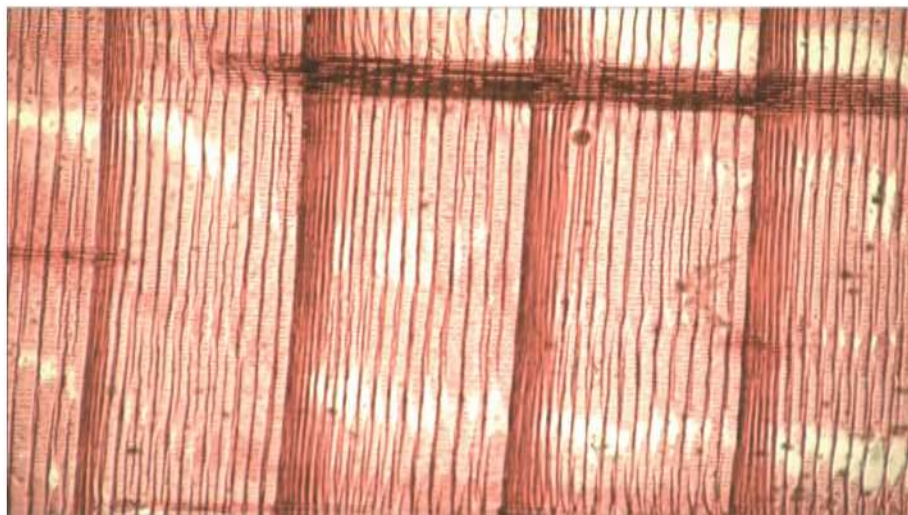
Figure II.XV. *Pinus ponderosa* magnification 40X



Transverse

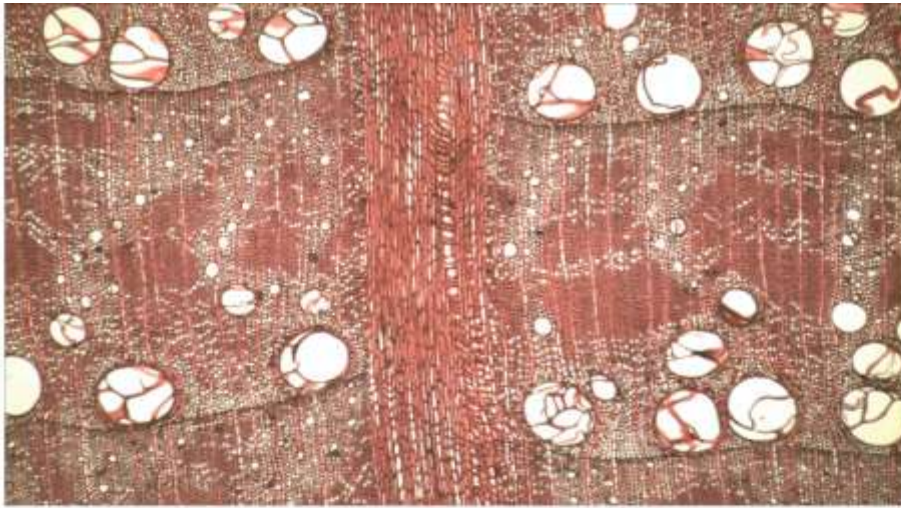


Tangential

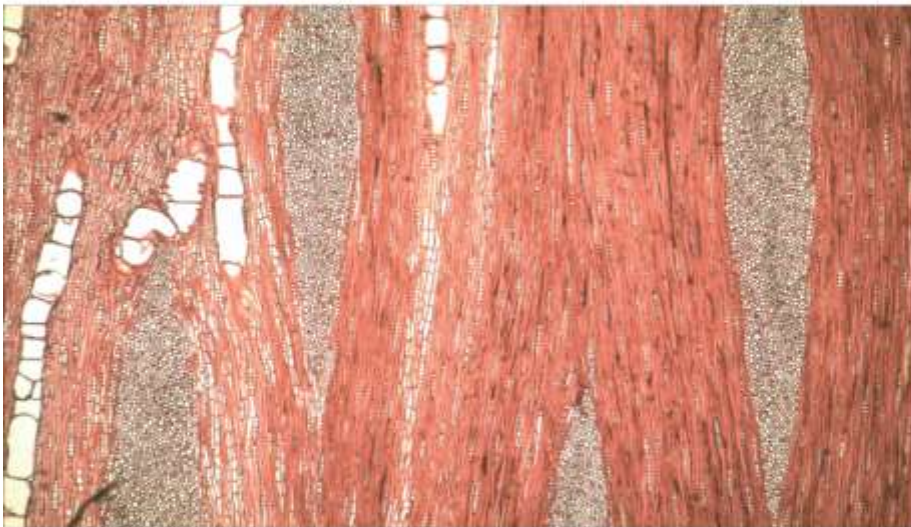


Radial

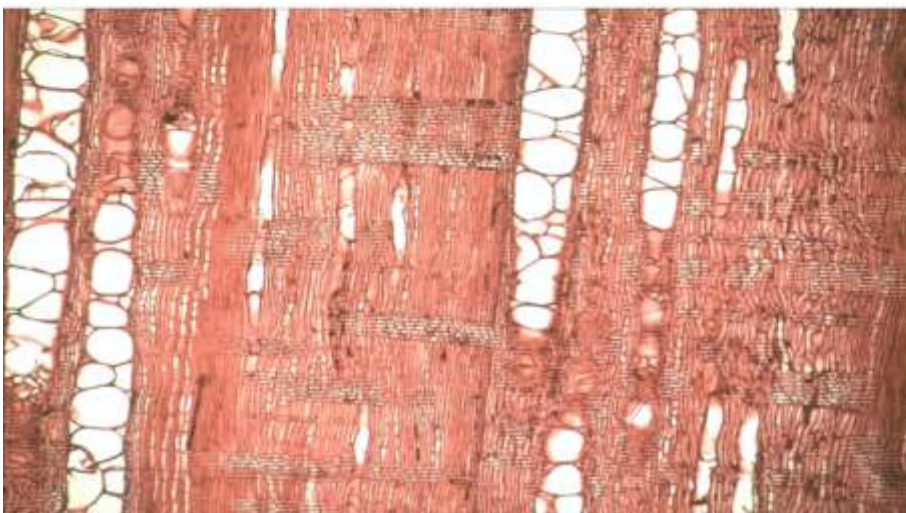
Figure II.XVI. *Pseudotsuga menziesii* magnification 40X



Transverse

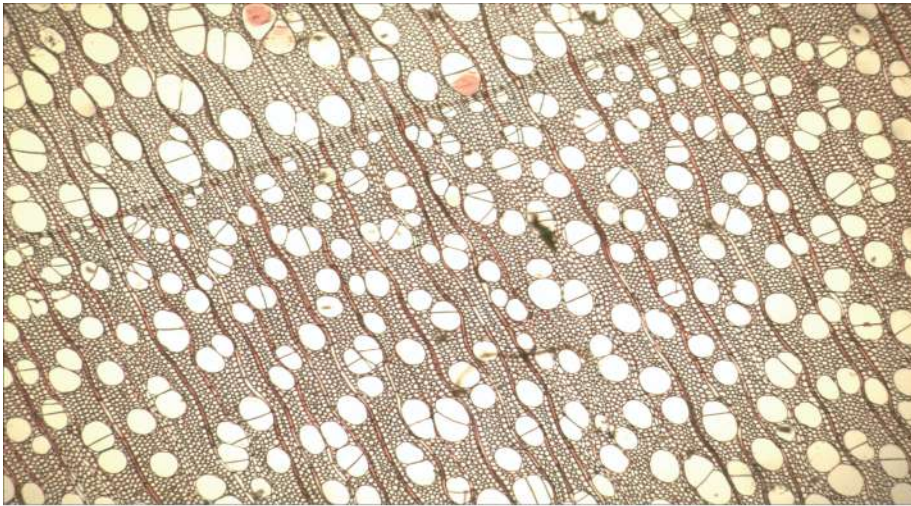


Tangential

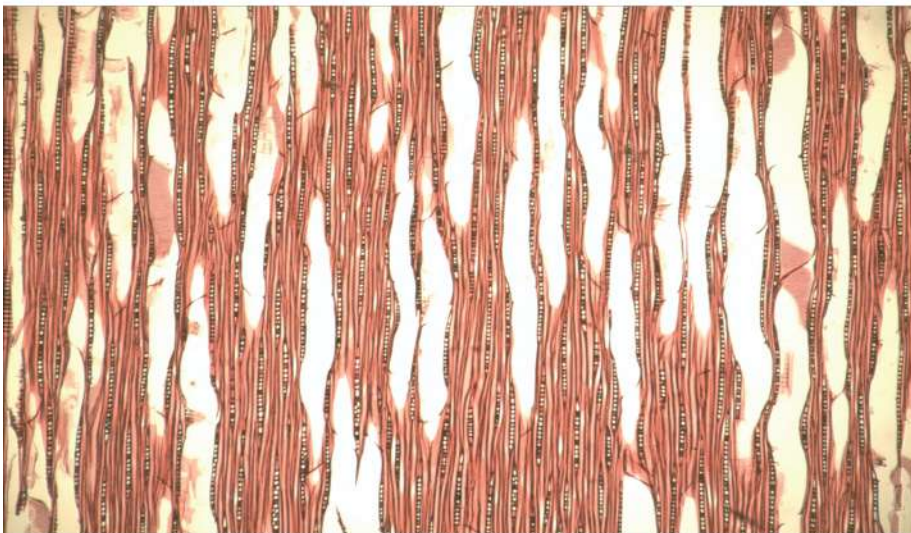


Radial

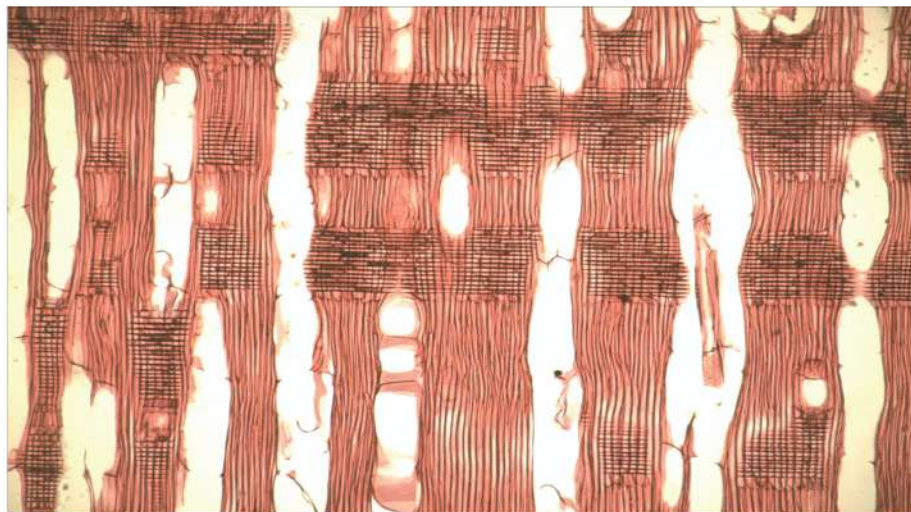
Figure II.XVII. *Quercus garryana* magnification 40X



Transverse

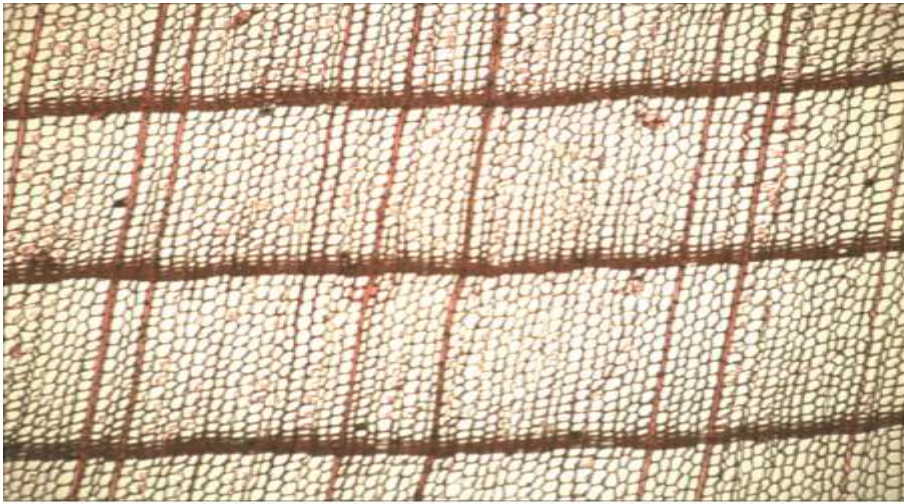


Tangential

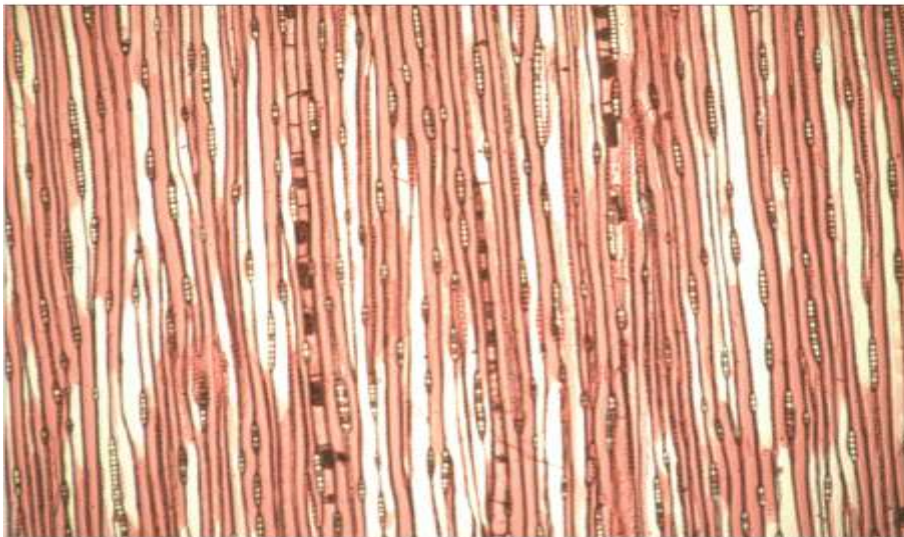


Radial

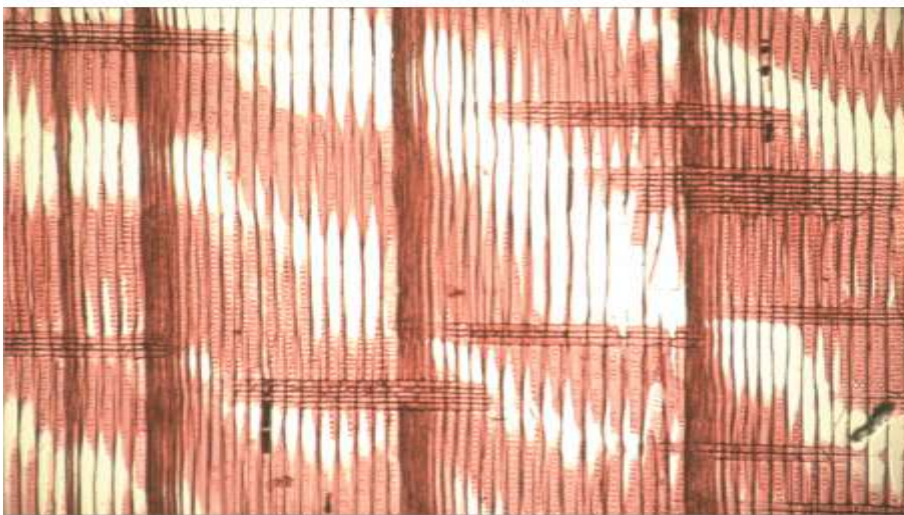
Figure II.XVIII. *Sallax* sp. magnification 40X



Transverse



Tangential

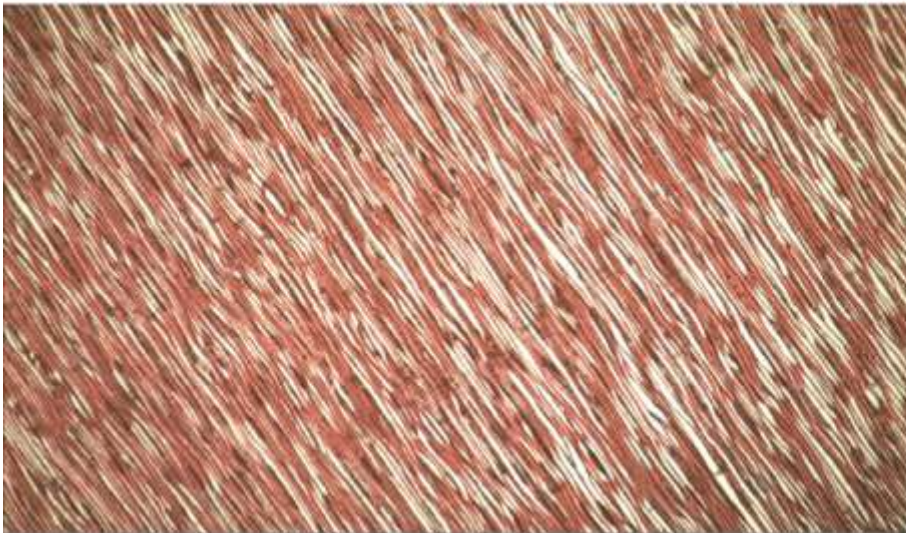


Radial

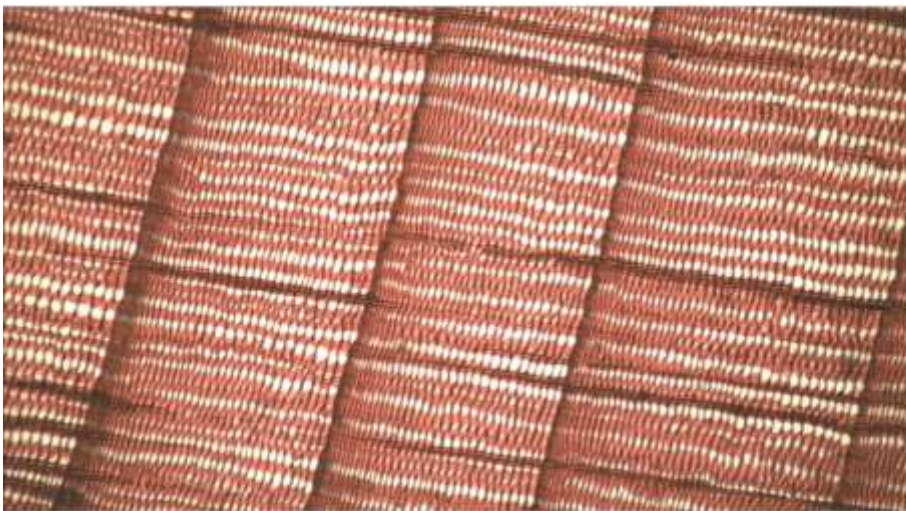
Figure II.XIX. *Sequoia sempervirens* magnification 40X



Transverse



Tangential



Radial

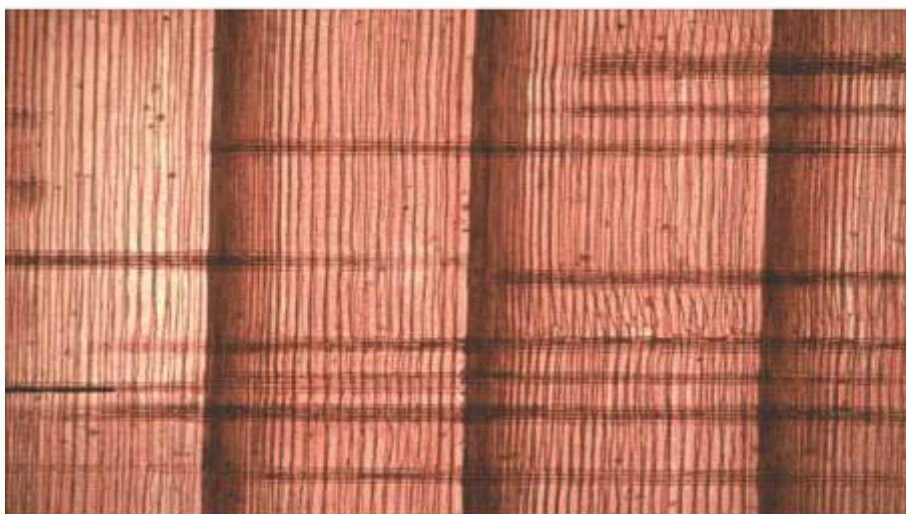
Figure II.XX. *Taxus brevifolia* magnification 40X



Transverse



Tangential

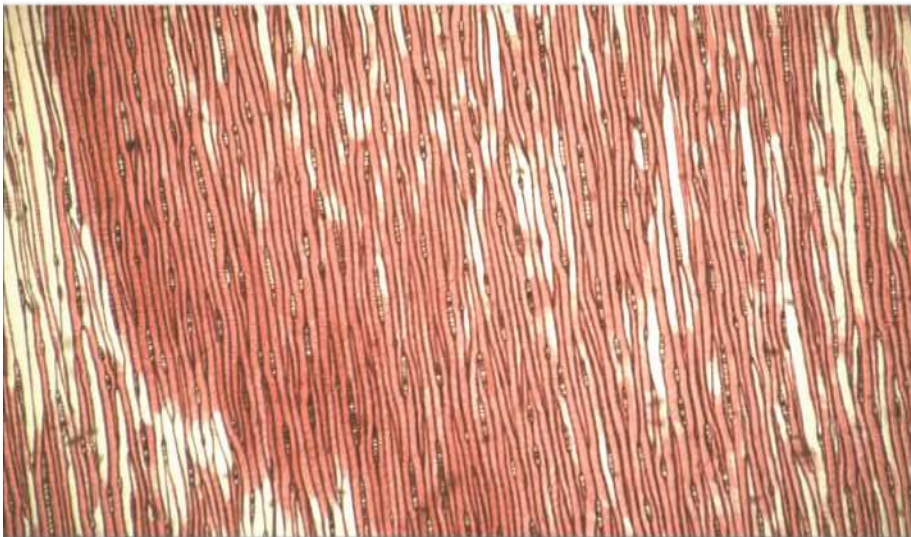


Radial

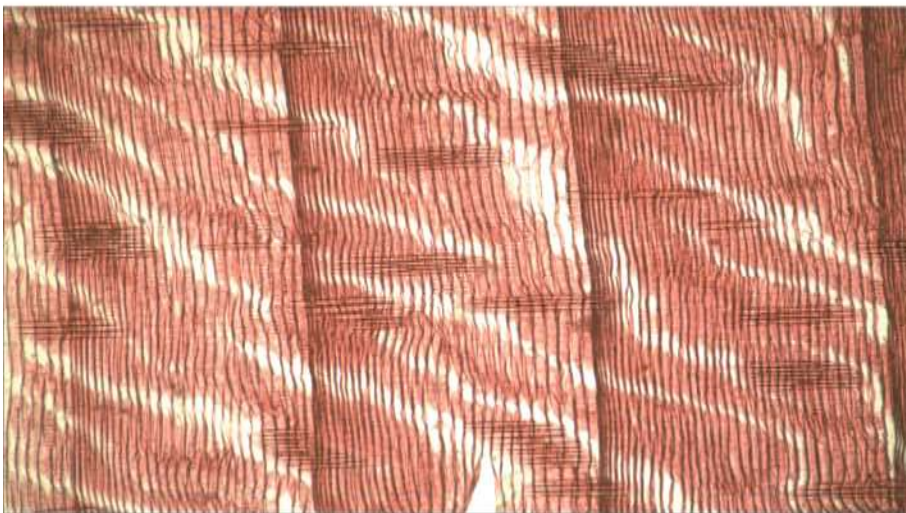
Figure II.XXI. *Thuja plicata* magnification 40X



Transverse

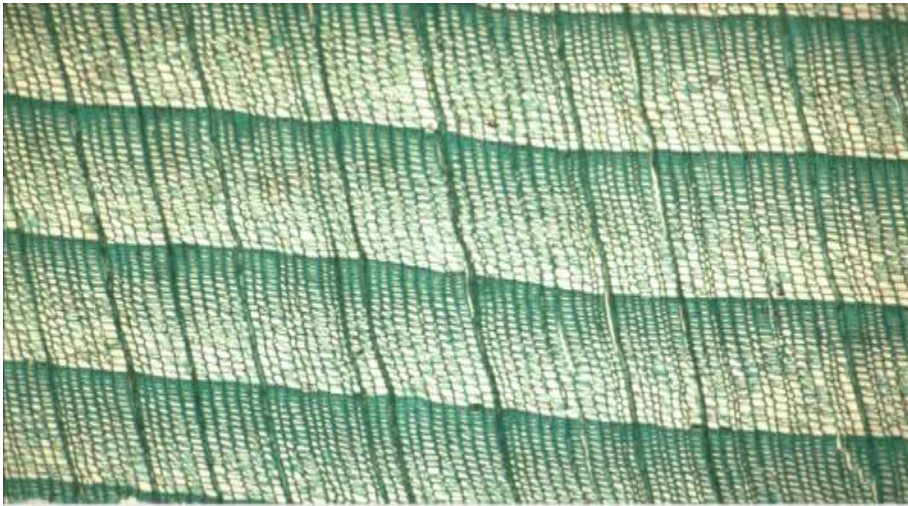


Tangential

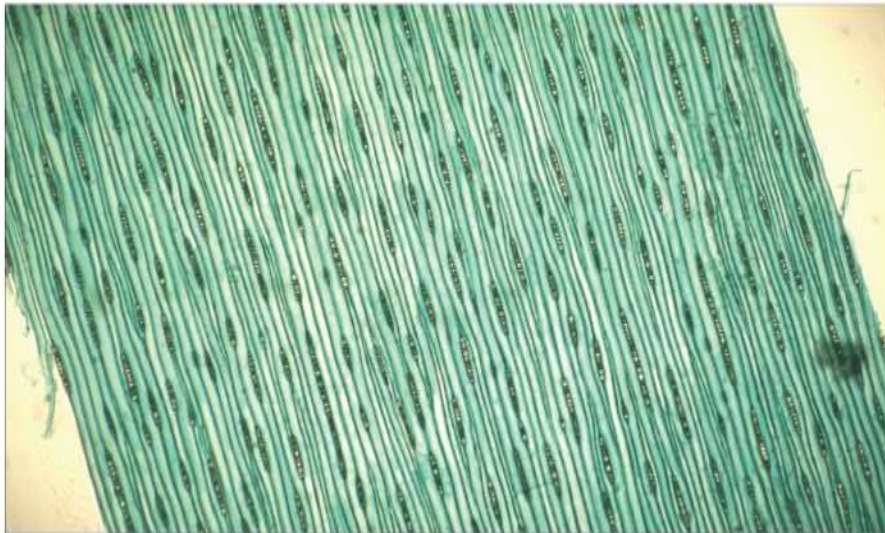


Radial

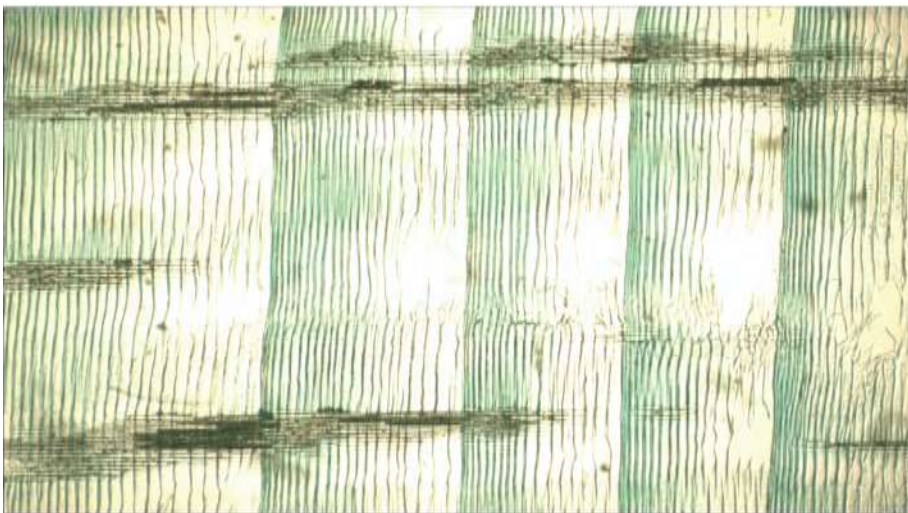
Figure II.XXII. *Torrey californica* magnification 40X



Transverse

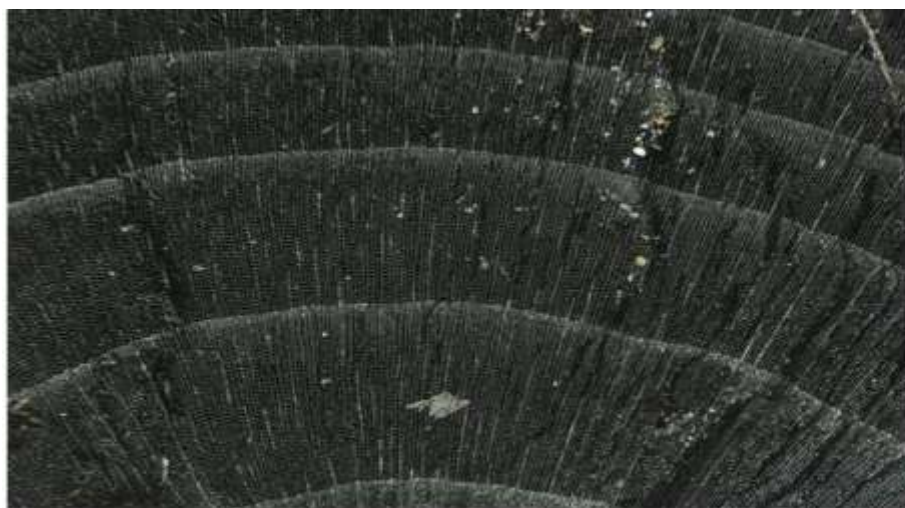


Tangential



Radial

Figure II.XXIII. *Tsuga heterophylla* magnification 40X



Transverse



Tangential



Radial

Figure II.XXIV. *Abies grandis* charcoal, amgnification 100X



Transverse



Tangential

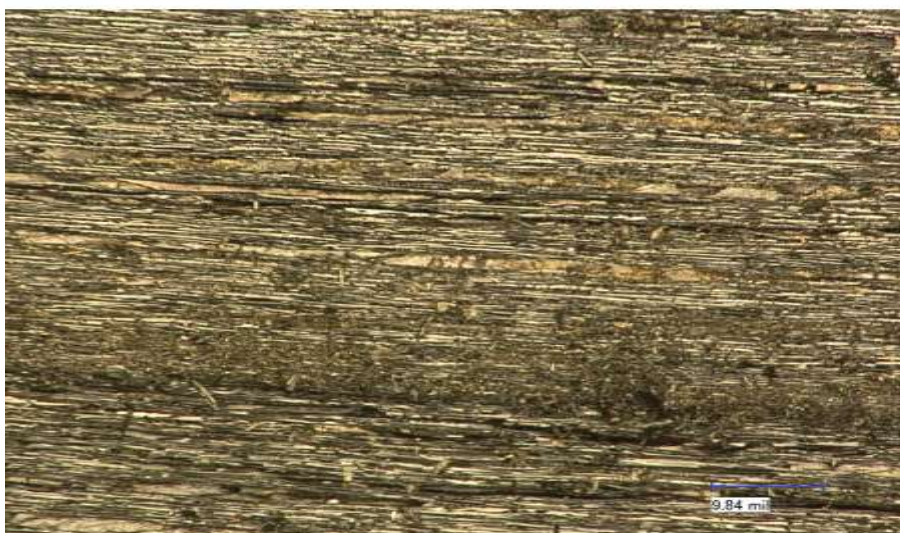


Radial

Figure II.XXV. *Acer macrophyllum* charcoal, magnification 100X



Transverse



Tangential

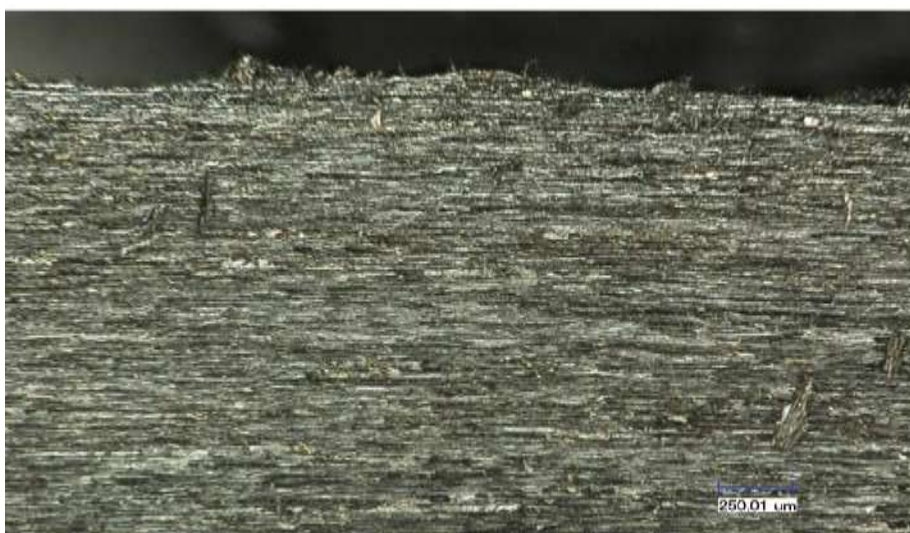


Radial

Figure II.XXVI. *Alnus rubra* charcoal, magnification 150X



Transverse



Tangential



Radial

Figure II.XXVII. *Arbutus menziesii* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXVIII. *Chamaecyparis nootkatensis* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXIX. *Larix occidentalis* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXX. *Picea sitchensis* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXXI. *Pinus contorta* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXXII. *Pinus ponderosa* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXXIII. *Pseudotsuga menziesii* charcoal, magnification 100X



Transverse



Tangential



Radial

Figure II.XXXIV. *Quercus garryana* charcoal, magnification 100X