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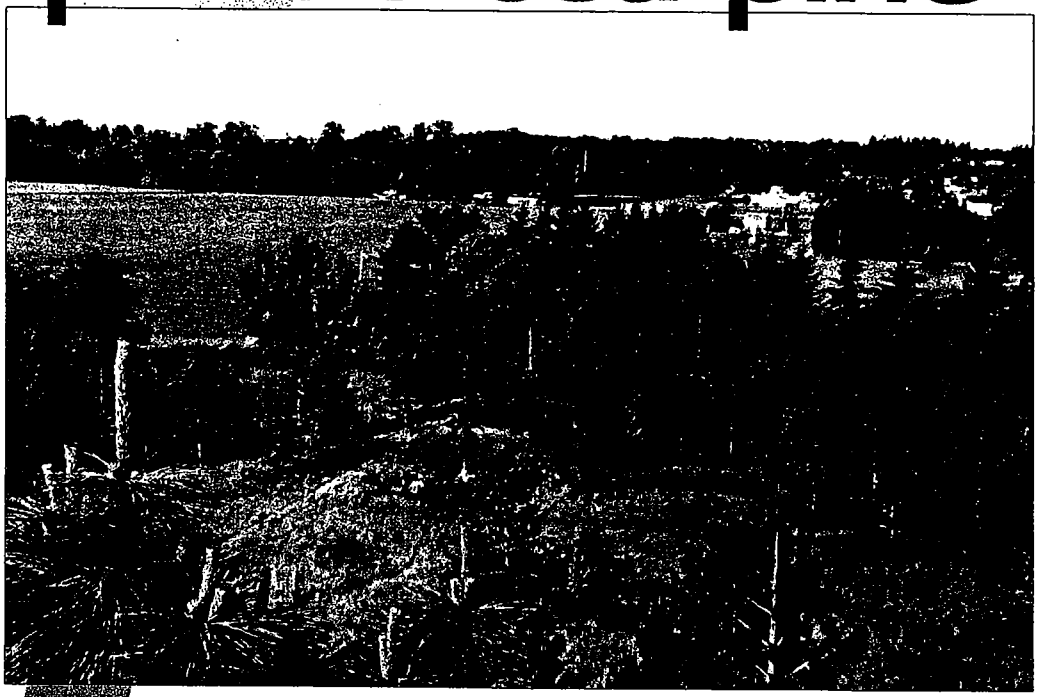
EXHIBIT 1

Establishing & managing

ponderosa pine



in the Willamette Valley

OREGON STATE UNIVERSITY
EXTENSION SERVICE

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Contents

1·2 3

An overview of Willamette Valley ponderosas

R. Fletcher and D. Hibbs

Many people are surprised to learn that ponderosa pine (*Pinus ponderosa*), a common tree east of the Cascade Mountains, also is native to the Willamette Valley in western Oregon. No one is quite sure how ponderosa got into the Willamette Valley, but the local race is genetically different from those growing east of the Cascades.

This management guide will describe what is known about this unique race of ponderosa pine, how to establish, manage, and protect it on rural and urban sites in the Willamette Valley, and how to harvest and market ponderosa pine timber.

Figure 1.—An old-growth ponderosa pine logging operation near Lebanon, OR in 1912.

History of ponderosa pine in the Willamette Valley

The year was 1852, and white settlement of the Willamette Valley was well underway. The town of Monroe was just getting its start with a new water-powered sawmill. The mill's records indicate that it cut ponderosa pine exclusively for several years until the supply ran out.

Other reports and studies of ponderosa pine in the Valley picture ponderosa in scattered pure stands or mixed in groves with Douglas-fir, ash, and oak. Two studies using pollen counts in deep cores from Valley bogs track pines' presence for the last 7,000 to 10,000 years. The hypothesis is that lodgepole was the dominant pine until about 7,000 years ago when a major climate shift removed lodgepole and brought in ponderosa. Pollen counts covering these 7,000 years indicate that ponderosa pine, while widespread across the Valley, has never been the dominant vegetation type.

Undoubtedly there is some connection between indigenous peoples' practice of burning and the distribution of pine in the Valley at time of white settlement. Ponderosa pine is very common in other fire-impacted landscapes and is quite tolerant of ground fires, especially when the trees are mature. The frequent ground fires set by native peoples very likely resulted in the widely spaced groves of "yellow pines" (ponderosas), surrounded by grass prairie, which confronted early settlers.

Surveyors, botanists, and historians in the 1850s recorded yellow pines in oak woodlands, on areas subject to flooding, and on foothill slopes and ridges where they were widely spaced and mixed with oak and Douglas-fir. These open stands have been called savannahs.

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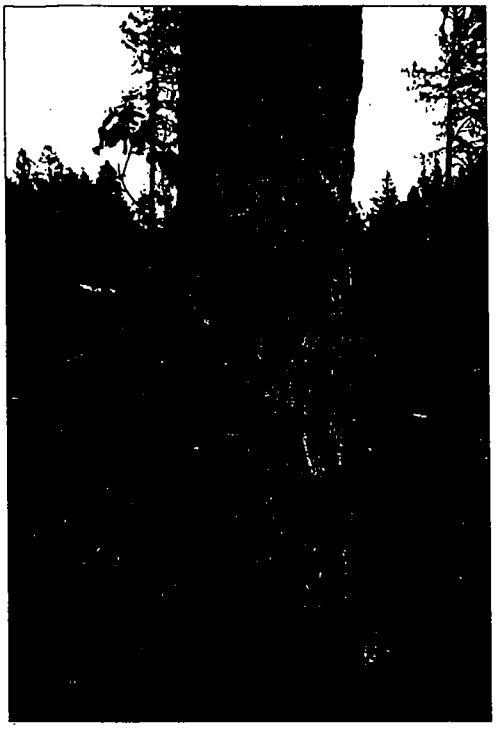

Figure 2.—Old-growth ponderosa pine on private forestland near Brownsville, OR.

Willamette Valley ponderosa's genetic difference from ponderosa east of the Cascades was the focus of a pine-race study begun in 1928 by Thornton Munger and T.J. Starker. The study featured seed sources from throughout the western United States, planted on six field sites. Included were seven sources east of the Cascades and three westside sources. The latter included Peoria (south of Corvallis, along the Willamette River); El Dorado, California, in the Sierras south of Sacramento; and Steilacoom, Washington, near Olympia.

The latest measurement of the study, completed by Roy Silen, found that after 65 years, only the westside sources were still alive and actively growing at the Willamette Valley test site on McDonald Forest, near Corvallis. Trees from eastside sources all appeared poorly adapted for the weather and pest conditions in the Willamette Valley.

The bottom line is that one should not plant ponderosa pine trees from eastside seed sources in the Willamette Valley. While the trees may survive 15 to 20 years, they aren't likely to reach mature size and may become carriers for all sorts of pine pests.

Another lesson from the Willamette Valley test site is that even the trees from westside sources that were still living were not doing very well. This might be expected because the McDonald Forest site was not on a soil and exposure common for pine in the Willamette Valley.

Concern about the dwindling supply of native Willamette Valley ponderosa pines, and the realization that the local source could not be replaced with eastside sources, led to the formation of the Willamette Valley Ponderosa Pine Conservation Association, in 1996.

A group of local foresters, landowners, and scientists had been studying the local pines for 15 years and had begun propagating local parent sources. The Association seeks to further this work in restoring ponderosa pine to the Willamette Valley through research, education, and increased availability of seed from the local race of pines. To date, more than 900 native stands have been mapped, and about 150 individual sources have been grafted into a seed orchard near St. Paul, Oregon.

The Association's work will be complete when landowners can buy native planting stock readily and when research has shown how best to plant and grow this tree.

Figure 3.—Principals in the Willamette Valley Ponderosa Pine Conservation Association admire the Robert H. Mealey gene conservation planting of Willamette Valley ponderosas at the State of Oregon seed orchard near St. Paul, OR.

Ponderosa pine growing sites in the Willamette Valley

Ponderosas grow on a wide variety of both rural and urban sites throughout the Willamette Valley. Native groves are in Beaverton, in parks and on the grounds of such prominent businesses as Nike. Scattered trees and small groves are found on neglected bottomland farm sites the whole length of the Valley. Along riverbanks, it often is associated with black cottonwood, ash, or bigleaf maple. In the foothills, ponderosas occupy the harshest of forest sites, where Douglas-fir and other species cannot dominate. On sites suitable for other conifers, ponderosa may grow for some time but eventually is shaded out by the taller, more dominant species. Commonly, ponderosas are found in association with Oregon white oak and many times in thick patches of poison-oak.

Native ponderosas are commonly found on three general soil types:

1. Poorly drained, heavy clay soils on the Valley bottom or in the low foothills
2. Shallow, rocky clay soils in the Valley foothills
3. Well-drained, sandy soils in the flood plain of the Willamette River and its tributaries

These soil types represent the low end of growth potential for ponderosa pine. It grows better on soils with good drainage and depth.

Figure 4.—Ponderosa pine replaces Douglas-fir on a typical, wet Willamette Valley site.

Benefits of planting Valley ponderosa pine

Willamette Valley ponderosa pine plantings can meet a number of objectives that include producing valuable wood, filling the need for a stately conifer in an urban setting, and restoring woodland and riparian habitat.

Wood production

Wood from Willamette Valley ponderosa pine was an important building material for the settlers in the Valley in the 1840s and 1850s. Next to Douglas-fir, ponderosa pine has been the most widely used species for wood products in Oregon during the past 150 years. Most of it has come from eastern and southern Oregon; however, new plantings in the Willamette Valley have the potential to once again fuel a ponderosa-pine-based wood industry later in this century. Excellent growth rates and good wood quality will make maturing plantings in the Willamette Valley an attractive option for wood purchasers in the future.

Ornamental trees

Most native conifers in the Willamette Valley are poorly suited to urban uses. Not so, however, with ponderosa pine. Its deep rooting structure, tolerance of drought and

Figure 5.—Ten-year-old Valley ponderosa agro-forest on Rising Oak Ranch near Lebanon, OR. Spacing is 9 feet between trees and 18 feet between rows.

1.5

flooding, and stately form make it an ideal choice for parks, schools, factories, and other urban locations where a large conifer is desired. Many fine specimens are in urban areas such as Eugene (Figure 6) and Beaverton.

Habitat restoration

Habitat restoration is the order of the day for streams, rivers, and oak savannahs throughout the Willamette Valley.

Ponderosa grew historically in much of this habitat, so it is only natural that it would be a key species to reestablish. On the dry knobs and prairies, ponderosa is being intermingled with oaks and firs. In riparian areas or wet clay soils, it is planted alone or mixed with ash, maple, oak, and cottonwood.

One of the main features it offers for these habitat plantings is a long-lived conifer that will provide nesting, shade, and other habitat features while living and large woody debris for a healthy riparian system after it dies.

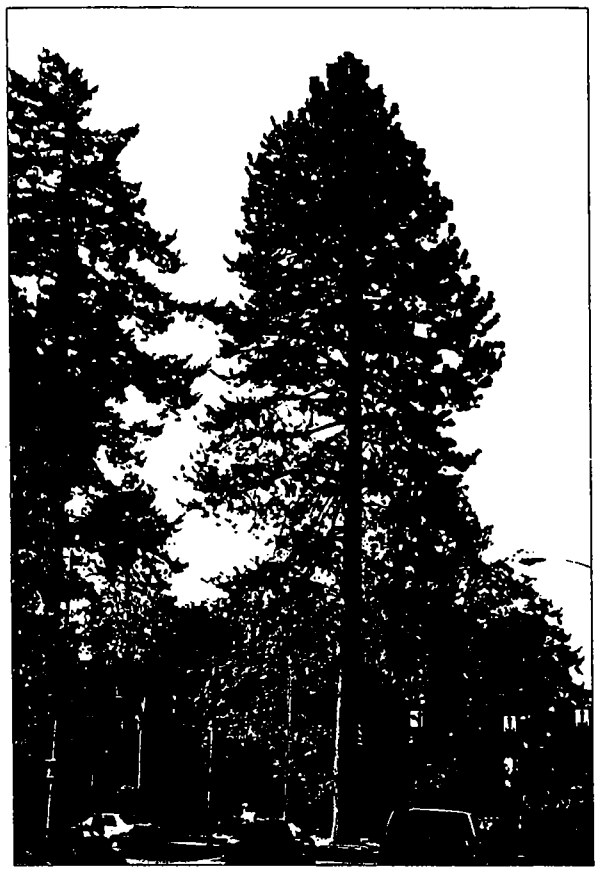

Figure 6.—Mature ponderosa pines thrive on city streets in Eugene, OR.

Figure 7.—Ponderosa pine planted in a riparian restoration project near Brownsville, OR.

1-6

Managing a new ponderosa pine plantation

H. Dew and B. Kelpsas

Attention to the details of site preparation, stock type selection, and plantation maintenance is probably more critical in establishing Valley ponderosa pine than any other species planted west of the Cascades. This is because of the tough sites that ponderosa pine is expected to occupy.

No other tree is asked to survive and grow in conditions as adverse as these. From rocky, dry, and poison-oak-infested south slopes to marshy, heavy clay that cracks wide open in summer, sites that won't grow another commercial tree are typically where this durable species is planted.

For more information on site preparation and general reforestation topics, refer to OSU Extension publications EC 1188, "Site Preparation: An Introduction for Woodland Owners"; EC 1498, "Successful Reforestation: An Overview"; EC 1504, "The Care and Planting of Tree Seedlings on Your Woodland"; EC 1196, "Selecting and Buying Quality Seedlings"; and PNW 33, "Plant Your Trees Right" (see page 39).

Site selection

Many times the search is for a tree that will grow on a site where a planting has already failed. It is true that ponderosa pine will grow in a flood-prone area, but is this really the place to grow trees at all? Often, the best sites are reserved for more profitable species such as Douglas-fir or western redcedar, as well they should be, but ponderosa will do very well on some good sites and may be the best choice for them. If you have questions about your site's suitability for growing ponderosa pine, contact your local office of the OSU Extension Service or Oregon Department of Forestry.

Figure 8.—Pine shelterwood unit near Brownsville, OR, cleared of debris and ready for planting.

Site preparation

Site preparation is the most important step in reforestation with any species. Improper site preparation results in poor growth and a much higher risk of plantation failure. More tree-planting failures can be attributed to poor site preparation than to any other cause.

At the very least, make sure the site is free of weeds and grass for the first few years. Competing vegetation places moisture stress on newly planted trees with poorly established roots and is a primary cause of plantation failure. Whether you use herbicides, mulch mats, or hoeing, you must control vegetation to ensure the seedlings' survival and growth. An adequate

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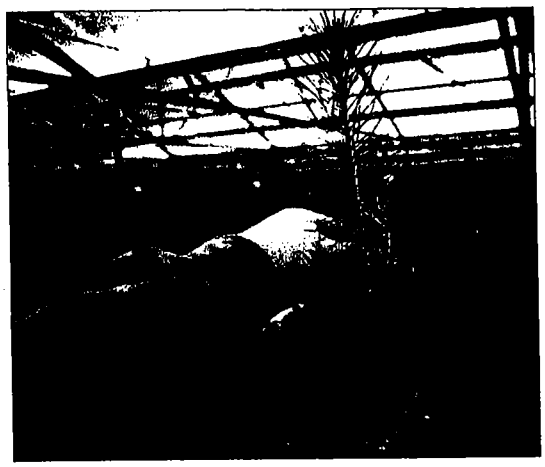


Figure 9.—One-year-old container seedling at Kintigh's Nursery, Springfield, OR.

weed-free space around each tree generally is thought to be a radius of about 2 to 3 feet for the first 3 years.

The secondary cause of plantation failure is girdling damage caused by rodents that use the grass for cover (see Chapter 7). Vegetation control is the best way to prevent rodent damage.

Site preparation sprays

The best feature of site preparation sprays compared to herbicide applications after planting is that they involve little risk to seedlings you will plant later. You also have more flexibility in timing sprays when weather is favorable.

In applying any herbicide, follow the instructions on the label regardless of what is said elsewhere, including in this publication. The herbicide label is the legal guide to how that chemical may be used. Also, you must notify the Oregon Department of Forestry any time you plan to apply an herbicide on forestland, and you might also have to be licensed by the Oregon Department of Agriculture. In addition, you must report any pesticide use on your forestland annually to the Oregon Department of Forestry.

Table 1 lists the most common herbicides used for site preparation in ponderosa plantings.

Glyphosate and products like imazapyr work well on most species but are weaker on blackberries. Products such as metsulfuron and triclopyr often are added to spray mixes to improve blackberry control. These commonly are applied in midsummer or fall before planting. Evergreen weed species such as Scotch broom, snowbrush, manzanita, and madrone are best treated with triclopyr, imazapyr, or 2,4-D from spring through summer.

Herbaceous weeds also can be controlled for the following growing season by adding sulfometuron to the fall site-preparation mix. Pine seedlings planted the following spring can develop in relatively weed-free environments. Table 1 gives more detail on target vegetation.

Table 1. Herbicides and target vegetation

Chemical name	Target vegetation
glyphosate	Deciduous brush, grasses, forbs, bracken fern
imazapyr	Maples, madrone, deciduous brush and trees
atrazine	Annual grasses, grass and forb germinants
2,4-D	Alder, madrone, manzanita, thistles, and forbs
metsulfuron	Blackberries (*Rubus* spp.), ferns, deciduous brush
triclopyr	Blackberries, Scotch broom, evergreen brush
sulfometuron	Grasses and forbs; suppresses blackberries
clopyralid	Thistles, some forbs, elderberry
hexazinone	Established grasses and forbs

Planting considerations

The two stock types are containerized and bareroot. Both come in many different sizes; generally, the biggest are best. Containerized seedlings have many advantages. One of the best is that timed-release fertilizer can be incorporated into the planting medium to give the tree a boost the first year after planting. This is a great benefit on some of the poor sites where ponderosa is expected to grow. Also, containerized trees generally are easy to plant and suffer less transplant shock than bareroot seedlings.

The disadvantages to using containerized trees are (a) their high cost relative to size and (b) the seedlings' vulnerability to animal browsing, because they tend to have more lush growth. Sometimes container seedlings must have tubelike tree protectors, which can be as expensive as the seedlings to purchase and install.

Bareroot seedlings can be cheaper to purchase, but are often hard to find due

to the current shortages of seed and the unwillingness of many purchasers to wait two seasons for their seedlings versus one for container seedlings.

Seed sources are particularly important. Be sure to ask whether the parent seed was truly Willamette Valley ponderosa pine seed. Seed from eastside sources will not grow well on the westside, as many plantations have proved.

Whether the seed comes from the north or the south Valley doesn't seem to make a large difference. Getting a source that is close to your plantation site is, however, highly desirable.

Until the Willamette Valley ponderosa pine seed orchard at St. Paul begins to produce seed, infrequent wild crops are still the only source for local nurseries, so seedling availability may be an issue for the next 5 years or so. When the orchard begins to produce seed, it will be the best available.

Use pesticides safely!

- **Wear** protective clothing and safety devices as recommended on the label. **Bathe or shower** after each use.
- **Read the pesticide label**—even if you've used the pesticide before. Precisely follow label instructions (and any other instructions you have).
- **Be cautious** when you apply pesticides. Know your legal responsibilities as a pesticide applicator. **You may be liable** for injury or damage resulting from your pesticide use.

Figure 10.—Mixed plantings of ponderosa pine and Douglas-fir might be a good idea on sites where there is a question about which species is better suited.

Plantation spacing depends on management goals. Plant in a way that gives you the most flexibility for future management decisions:

- Will you manage for an uneven-age or an even-age stand?
- Do you want a mixed-species stand?
- What is the site's carrying capacity?
- Will the stand be thinned later?

Discuss these questions with your OSU Extension forester or a forestry consultant *before* planting. Common spacing for newly planted ponderosa pine plantings is about 10 to 12 feet apart.

Vegetation management around newly planted ponderosa pines

No matter which type of stock you choose to plant, controlling competing vegetation around newly planted trees is essential for good survival and growth. Strategies to manage competing vegetation involve physical removal through scalping or tilling, treated paper or other mats that smother competing weeds, and herbicides. For more information on weed control, refer to the current edition of the "Pacific Northwest Weed Management Handbook" (see page 39).

Figure 11.— Blackberry competition has left this ponderosa pine seedling deformed and weak.

Scalping or tilling to control vegetation can be effective if you are persistent and if you remove the vegetation in a way that does not damage the tree seedlings' tops or roots.

Scalping works best before the trees are planted. Tillage can work before planting and up until the tree roots begin to invade the scalped area.

One disadvantage of tillage is that it tends to leave competing weeds closest to the trees. Treated paper or other mats can be effective around newly planted trees if they are properly installed and maintained. Their main drawbacks are high cost and the fact that they sometimes provide cover for mice, which will girdle the young trees.

Ponderosa pine is more sensitive than Douglas-fir to many herbicides used in forestry. In addition, various surfactants and oils that are added to spray mixtures can increase the risk of pine damage.

Take care when using herbicides over seedlings, to avoid injury or death. In many cases, vegetation management around pine involves balancing seedling injury with weed control.

Two spraying strategies for controlling weeds around newly planted ponderosas are:

- Directed spraying, and
- Broadcast release applications

Directed spraying

Directed spraying uses herbicides in a spray directed around seedlings but not contacting them. Spot spraying with backpack sprayers is an example. Using a spray shield is another technique. The risk of injury is limited to seedlings that are sprayed or are overdosed through the soil. This method also allows you to use non-selective herbicides and a much wider effective spraying window of time.

Herbaceous weeds can be controlled effectively at any time with spot applications of glyphosate around seedlings. Since glyphosate has no soil activity, overdosing through the root system is not a risk. Often, glyphosate can be mixed with soil-active herbicides to give longer lasting pre-emergent activity. Using this treatment with spring residual soil-active products such as sulfometuron, atrazine, or hexazinone requires precise sprayer calibration and application in order to avoid damaging seedlings through the soil. Be very careful to keep glyphosate off the foliage, however; it is toxic to the plant.

Blackberries and Scotch broom are often problems on Valley sites. Both are treated effectively with directed foliar spot applications of triclopyr. Unfortunately, pine is extremely sensitive to any triclopyr spray drift, and triclopyr ester is volatile at warmer temperatures, so take care.

Blackberries are best treated in fall after conifer budset. Scotch broom can be treated any time during the growing season, but applications before conifer budbreak or after budset in the fall may be safer for trees.

[illegible] forest herbicides
[illegible] tolerance for release applications

Chemical name	Pine tolerance [1]	Use over pine?
atrazine	excellent	yes
imazapyr	marginal [2]	site prep only
metsulfuron	poor	site prep only
triclopyr	poor	no – only as directed spray
2,4-D	poor to fair	possible but risky
sulfometuron	good	yes
glyphosate [3]	fair to good	yes
clopyralid	excellent	yes
hexazinone	excellent	yes

[1] Herbicide injury is variable and is highly dependent on rate, timing, and tree condition.

[2] Imazapyr products can reduce shoot growth the next growing season.

[3] Some glyphosate products contain surfactant, which increases the risk of damaging pine.

1-10

Other evergreen species such as madrone, manzanita, and snowbrush also can be treated with a directed spray of triclopyr, 2,4-D, or imazapyr. However, these products can damage pine and should be used only as a site preparation or spot treatment. Larger weeds that cannot be efficiently controlled with a foliar spray from a backpack unit may be treated individually with a basal-bark application of triclopyr in an oil carrier.

Deciduous plants such as poison-oak, deerbrush, hazel, and bracken fern are sensitive to mid- to late summer foliar applications of glyphosate and/or imazapyr in water. Avoid spraying over pine, even though it has some tolerance to glyphosate (see the section on broadcast release applications, below). Maples and other hardwoods or brush often can be treated with a hack-and-squirt application using imazapyr, glyphosate, or triclopyr amine.

Broadcast release applications

Another strategy for vegetation control uses herbicides selectively over seedlings in a calibrated broadcast treatment. Application methods include helicopter, backpack waving wand, meter jet, and backpack with flat-fan spray tips.

This strategy might give the most complete weed control, but it also carries the greatest risk of damaging pine seedlings. In addition, not all herbicides can be used selectively over pine. Table 2 shows pine tolerance to foliar-applied herbicides.

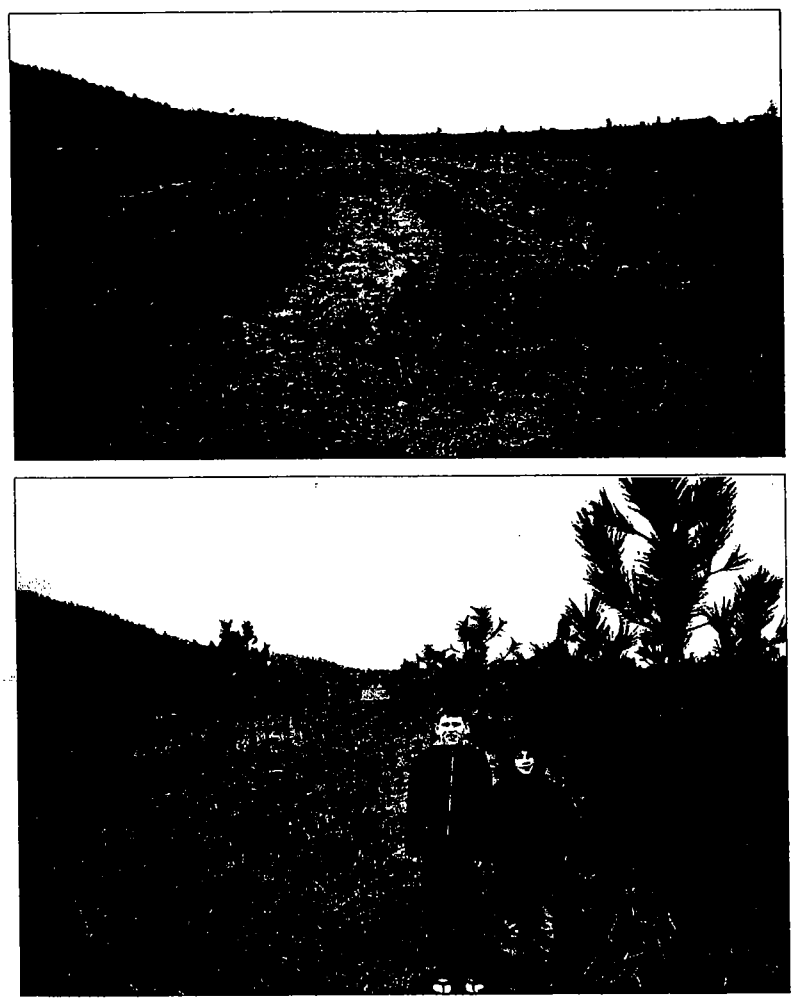
Broadcast release treatments for herbaceous weeds can be made selectively over newly planted or established pine with atrazine, sulfometuron, or hexazinone in spring before conifer budbreak.

Atrazine is least likely to injure pine but also has limited ability to control established vegetation. Ponderosa pine is extremely tolerant to hexazinone, which is a good choice on sites that have perennial grasses and forbs. Sulfometuron gives intermediate vegetation control; higher rates can affect seedling development temporarily on some sites.

Tank-mixes of these herbicides are effective and can help reduce per-acre costs. Note that all these products are soil active, so precise calibration is important to avoid overdosing seedlings.

Glyphosate products that contain no surfactant can be applied at reduced rates in spring before budbreak over established (second-year) seedlings. In western Oregon, sulfometuron also can be used over pine in spring or fall to suppress blackberries. Mixtures of sulfometuron and glyphosate as fall blackberry treatments may be a reasonable substitute for damaging triclopyr applications.

Thistles and some broadleaf plants are sensitive to clopyralid. Applications can be made at any time because clopyralid has little activity on pine or other conifers at any growth stage. Clopyralid has been a good addition to atrazine, sulfometuron, or hexazinone during spring weed control programs and makes a good substitute for the more injurious 2,4-D.



Figures 12a and 12b—A newly established ponderosa pine plantation near Lebanon, OR (top) and after five growing seasons (above).

Release applications of 2,4-D over pine have been made but usually cause some injury. Damage can range from mild to severe depending on weather, seedling growth stage, and spray adjuvants, among other variables.

Avoid adding oils or surfactants to spray mixes to improve selectivity. Spring treatments target madrone, manzanita, alder, and forbs. Since 2,4-D is the only herbicide for broadcast release pine programs on evergreen brush, some conifer injury may be acceptable. Applications in early spring before candle elongation or in fall after budset can help reduce risk of injury.

Unlike evergreen brush, deciduous brush species such as poison-oak, hazel, and deerbrush often are treated selectively over pine with glyphosate products. Typical release treatments are timed after budset in late summer or fall to reduce risk of damage.

Conifers still can be injured, however, especially if a surfactant is added or is in the formulation. The type of surfactant used with glyphosate over pine can have a very large impact on damage. Carefully screen new surfactant additions in small trials before using them in a full program. You also might want to consult with someone in the agricultural pesticides industry for recommendations on surfactants.

Because Valley sites often contain numerous plant competitors, no one herbicide will do the job in all cases. Combinations of these strategies probably will be the most effective on vegetation and least injurious to pines. Herbicide labels change frequently, so read and carefully follow the label on the product in hand.

1-12

Managing stands of Willamette Valley ponderosa pine

R. Fletcher

Both natural and planted stands of ponderosa pine can be managed using thinning, pruning, and fertilization, although little research has been done on these practices for the Willamette Valley race of ponderosa pine. What is known has been gathered from general observation, from small test plots, and from a survey of native stands by OSU Extension forester Max Bennett.

Natural stand development

It is difficult to define what normal stand development means for ponderosa pine in the Willamette Valley.

Historical stands apparently were either scattered groves of large trees in grassy bottoms or mixed-species stands in the foothills. In either case, the indigenous tribes' broad-scale burning shaped those forests in ways not available today.

Current stands have come about by colonizing neglected areas or soils with severe limitations for other tree species. The stands we see today are much denser than their counterparts in the past. What this means for future development and growth is uncertain. However, because ponderosa pine is a shade-intolerant species, preferring open spaces, it is likely that the high stocking will be reduced over time, either through insect and disease outbreaks, or some weather-related event, or by selective thinning.

Expected growth of Valley ponderosa pine stands

Anderson's 1938 study on central Willamette Valley ponderosas reported young ponderosas grew rapidly, but growth rates peaked by about 30 years of age. The small sample of trees had a 20-year-old tree with a 15-inch diameter at breast height (DBH), while a 100-year-old tree was only 34 inches in diameter. The pine races study that Munger began in 1928 showed a height growth spurt between 20 and 30 years of age, but the trees from the best seed source in the study have continued to grow well in height up to their last measurement at 65 years of age.

Max Bennett's recently completed study of 16 native Willamette Valley ponderosa stands on 12 different soil types found a wide variety of growth rates, depending on soil type (Table 3, page 12). Site indexes (estimates of site productivity based on

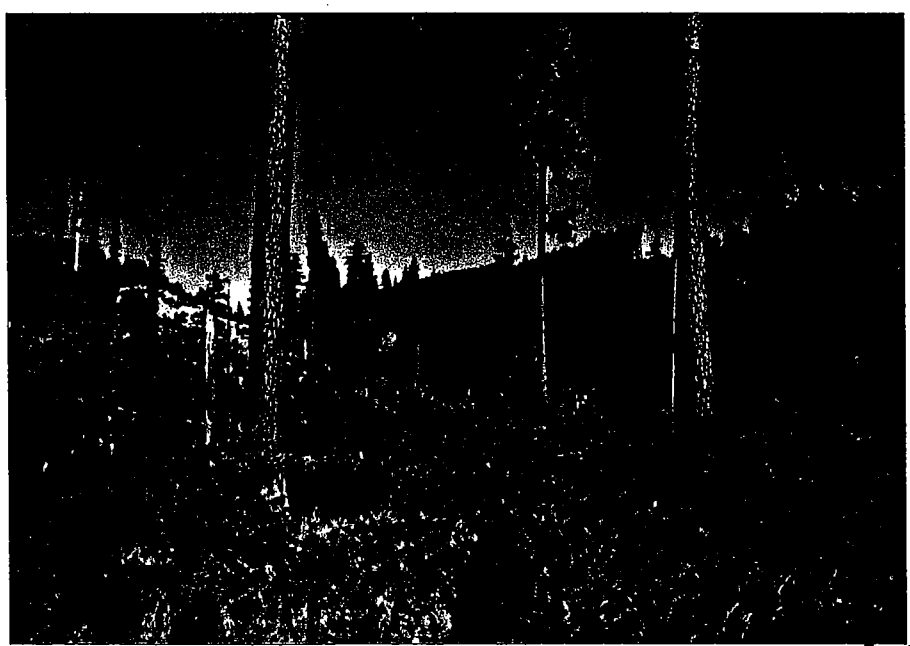


Figure 13.— Regeneration of a natural stand of ponderosa pine old growth on Willamette National Forest, near Oakridge, OR.

Figure 14.—Native, 40-year-old ponderosa pine stand on wet soil near Lacomb, OR.

how tall a tree of a given species will grow on a site in a given number of years) for each site were extrapolated from existing site index curves from ponderosa pine in southwest Oregon, based on expected total height at 50 years.

On most sites, ponderosas are expected to grow nearly 100 feet in the first 50 years. Exceptions were on very severe sites where the high water table and shallow soils converged. When these trees will slow down or stop growing taller is not known and undoubtedly will vary widely by soil type, but large specimen trees on suitable soils have grown up to 150 feet tall.

Growth of Willamette Valley [illegible]

Soil type	Height	Age	Site index (50)
Bashaw silty clay loam	98	59	92
Dayton silt loam	84	42	98
Dixonville/Hazelair/Philomath	96	98	63
Dupee silt loam	110	56	101
Hazelair silty clay* loam	93	52	92
McBee silty clay loam	104	59	92
Philomath cobbly, silty clay*	87	42	104
Ritner cobbly, silty clay loam	101	54	95
Salem gravelly loam	111	63	93
Waldo silty clay loam	83	41	96
Witzel very cobbly loam	92	98	59

* An average of more than one site

No studies of volume growth per acre have been done. Currently, large stands of ponderosa are few, but they appear to have volumes similar to local Douglas-fir stands of similar ages. The exception may be on the very severe (either wet or dry) sites, where volumes per acre will be less.

Managing natural stands of Valley ponderosa pine

If you are one of the lucky Willamette Valley landowners with a natural stand of ponderosas on your property, your trees might benefit from thinning or possibly pruning if they are still pole size.

Thinning

Thinning spaces out trees and improves the health and vigor of the overall stand. The key feature is not what you cut but the stand left behind after harvest. It is these trees, generally referred to as crop trees, that will determine future growth and overall stand health. In deciding which will be crop trees, and which ones you'll remove, consider the following factors.

1. Overall stand age and stocking Stands that respond best to thinning are young, moderately stocked ones. Older stands (50 years plus) likely have passed the time when thinning will greatly benefit growth rates, unless the stand was previously thinned. Thinning an older stand still might make sense, however, if you want to reduce longer term competition for crop trees or to remove unhealthy trees. Very dense stands may need several light thinnings, spaced by recovery periods, to move the stand gradually to a healthy density.

Possibly the most important thinning is a very early one, while the trees are not yet of merchantable size. This precommercial thinning sets the growth curve for the future stand and can have a dramatic, positive impact on growth if done at the right time.

2. Type of future stand desired If you want an even-age stand, then it makes sense to space crop trees evenly for maximum

growth. If you want to develop an uneven-age stand, your selection may be more in groups, to provide open areas for young trees to establish.

3. Individual tree characteristics The arboricultural principle of "right tree, right place" works well for forest thinning, also. If your need in a particular spot is high growth, then leave the best growers. If you want to leave a wildlife tree, look for one with big branches and good nesting opportunities. Even trees with obvious defects can be valuable in providing habitat for cavity-nesting birds such as woodpeckers. If you plan a continual-selection thinning system to promote natural regeneration, then you want to get rid of the super-dominant trees and keep the vigorously growing medium-size trees that have narrow crowns and fine branches.

4. Individual tree spacing As trees get larger, they need more room to grow. Foresters' rule of thumb for this size–space relationship is based on diameter of the tree at breast height (DBH).

For example, a tree 12 inches in diameter might need 16 feet of space to be happy, while a 20-inch-diameter tree might need 24 feet. This often is referred to as the "D+ rule."

Although there is no known D+ relationship for Valley ponderosa pine, they likely need a bit more space than Douglas-fir because of their intolerance of shade. Ponderosa might be more comfortable at a minimum spacing of D+2 or D+3. For a tree 12 inches in diameter, this means the next closest 12-inch tree should be at least 14 or 15 feet away. You might want to space your 12-inch trees 18 to 20 feet apart (i.e., at D+6 or D+8), anticipating that they will continue to grow in diameter over time and eventually get back to the minimum D+2 spacing.

Other ways to keep track of tree spacings:

- On a per-acre basis, either by total number of trees, or
- Some other measure of density such as basal area (the cross sectional area of a tree, measured at breast height), or
- Relative density (the amount of basal area on a given stand compared to the maximum that can possibly grow)

For more information on measuring stand density, refer to OSU Extension publication EC 1190, "Stand Volume and Growth: Getting the Numbers" (see page 39).

As more becomes known about the Valley ponderosas, better per-acre guidelines will be developed.

Managing plantations of Valley ponderosa pine

During the past decade, thousands of acres of Valley pine plantations have been established in the Willamette Valley. These represent a very different type of forest stand than has ever existed naturally.

Historical records indicate that natural stands were widely spaced groves of large trees, intermixed with hardwood species such as oak and ash. The pine plantations of today represent fast-growing monocultures whose growth far exceeds that of their natural cousins. No management history of similar stands exists, so only time will reveal how these plantations will develop. Experience to date, however, suggests some practices that are useful in tending young plantations.

Thinning

One genetic trait in the Valley pine population is a wide variance in tree forms. Progeny from various parent trees differ vastly in such characteristics as forking, branch angle, number of branches, and growth rate. By years 5 to 10, characteristics of individual trees in plantations are easily distinguishable, and you can favor trees with characteristics suited to your objectives. For example, if timber production is a primary goal, trees with high wood-to-branch ratios and good growth can be favored in thinning programs. Likewise, in riparian plantings where lots of branching can be good for

Figure 15.—Five-year-old pine plantation on a good site near Albany, OR.

Base 100 Ponderosa Pine Site Index Tables _20/

Site Index		60	65			70	75			80	85
Tot. Age	BH Age	Site Ht. feet	Site Ht. feet	Tot. Age	BH Age	Site Ht. feet	Site Ht. feet	Tot. Age	BH Age	Site Ht. feet	Site Ht. feet
20	4	18	19	20	5	21	22	20	6	24	25
25	9	22	24	25	10	26	28	25	11	30	32
30	14	27	29	30	15	31	33	30	16	35	38
35	19	29	32	35	20	34	37	35	21	39	42
40	24	33	35	40	25	38	41	40	26	44	46
45	29	35	38	45	30	41	44	45	31	47	50
50	34	38	41	50	35	45	48	50	36	51	54
55	39	41	44	55	40	48	51	55	41	55	58
60	44	43	47	60	45	51	54	60	46	58	62
65	49	46	49	65	50	53	57	65	51	61	65
70	54	48	52	70	55	56	60	70	56	64	68
75	59	50	54	75	60	58	63	75	61	67	71
80	64	52	56	80	65	61	65	80	66	70	74
85	69	54	59	85	70	63	68	85	71	72	77
90	74	56	61	90	75	65	70	90	76	75	79
95	79	58	63	95	80	68	72	95	81	77	82
100	84	60	65	100	85	70	75	100	86	80	85
105	89	62	67	105	90	72	77	105	91	82	87
110	94	63	68	110	95	74	79	110	96	84	89
115	99	65	70	115	100	76	81	115	101	86	92
120	104	67	72	120	105	77	83	120	106	89	94
125	109	68	74	125	110	79	85	125	111	91	96
130	114	70	75	130	115	81	87	130	116	93	98
135	119	71	77	135	120	83	89	135	121	95	100
140	124	73	79	140	125	84	90	140	126	96	102
145	129	74	80	145	130	86	92	145	131	98	104
150	134	75	82	150	135	88	94	150	136	100	106
155	139	77	83	155	140	89	96	155	141	102	108
160	144	78	84	160	145	91	97	160	146	104	110

WIT20L 86

_20/ Wycoff, E., and Atterbury, T., Age-Site Index Regression Equations for Base 100 Tables CrownZellerbach Corp., FMSS, 90pp. 1974

IA-1

Base 100 Ponderosa Pine Site Index Tables

Site Index		90	95	100	105			110	115			120	125
Tot. Age	BH Age	Site Ht. feet	Site Ht. feet	Site Ht. feet	Site Ht. feet	Tot. Age	BH Age	Site Ht. feet	Site Ht. feet	Tot. Age	BH Age	Site Ht. feet	Site Ht. feet
20	7	27	28	30	31	20	8	33	36	20	9	39	40
25	12	34	36	37	39	25	13	41	45	25	14	51	53
30	17	40	42	44	47	30	18	49	53	30	19	63	66
35	22	44	47	49	52	35	23	54	57	35	24	59	62
40	27	49	52	55	57	40	28	60	63	40	29	66	69
45	32	53	57	60	63	45	33	66	69	45	34	72	75
50	37	58	61	64	67	50	38	71	74	50	39	77	81
55	42	62	65	68	72	55	43	75	79	55	44	82	86
60	47	65	69	73	76	60	48	80	84	60	49	87	91
65	52	69	73	76	80	65	53	84	88	65	54	92	96
70	57	72	76	80	84	70	58	88	92	70	59	97	101
75	62	75	80	84	88	75	63	92	97	75	64	101	105
80	67	78	83	87	92	80	68	96	101	80	69	105	109
85	72	81	86	90	95	85	73	100	104	85	74	109	114
90	77	84	89	94	98	90	78	103	108	90	79	113	117
95	82	87	92	97	102	95	83	107	111	95	84	116	121
100	87	90	95	100	105	100	88	110	115	100	89	120	125
105	92	92	97	103	108	105	93	113	118	105	94	123	129
110	97	95	100	105	111	110	98	116	121	110	99	127	132
115	102	97	103	108	114	115	103	119	124	115	104	130	135
120	107	100	105	111	116	120	108	122	127	120	109	133	139
125	112	102	108	113	119	125	113	125	130	125	114	136	142
130	117	104	110	116	122	130	118	127	133	130	119	139	145
135	122	106	112	118	124	135	123	130	136	135	124	142	148
140	127	108	114	120	127	140	128	133	139	140	129	145	151
145	132	110	117	123	129	145	133	135	141	145	134	147	154
150	137	113	119	125	131	150	138	137	144	150	139	150	156
155	142	114	121	127	133	155	143	140	146	155	144	153	159
160	147	116	123	129	136	160	148	142	149	160	149	155	161

HAZELAIR 123

Ibid Ponderosa Pine Site Index Tables

Base 100 Ponderosa Pine Site Index Tables

Site Index		130	135	140	145			150
Tot. Age	BH Age	Site Ht. feet	Site Ht. feet	Site Ht. feet	Site Ht. feet	Tot. Age	BH Age	Site Ht. feet
20	10	39	40	42	43	20	11	45
25	15	49	51	52	54	25	16	56
30	20	58	60	62	64	30	21	66
35	25	64	67	70	72	35	26	75
40	30	71	74	77	80	40	31	83
45	35	78	81	84	87	45	36	90
50	40	84	87	90	94	50	41	97
55	45	89	93	96	100	55	46	104
60	50	95	99	102	106	60	51	110
65	55	100	104	108	112	65	56	116
70	60	105	109	113	117	70	61	121
75	65	109	114	118	122	75	66	127
80	70	114	118	123	127	80	71	132
85	75	118	123	127	132	85	76	137
90	80	122	127	132	137	90	81	141
95	85	126	131	136	141	95	86	146
100	90	130	135	140	145	100	91	150
105	95	134	139	144	149	105	96	155
110	100	137	143	148	153	110	101	159
115	105	141	146	152	157	115	106	163
120	110	144	150	155	161	120	111	167
125	115	147	153	159	165	125	116	170
130	120	151	156	162	168	130	121	174
135	125	154	160	166	172	135	126	178
140	130	157	163	169	175	140	131	181
145	135	160	166	172	178	145	136	184
150	140	162	169	175	181	150	141	187
155	145	165	172	178	184	155	146	191
160	150	168	174	181	187	160	151	194

PHILOMATH 131

Ibid Ponderosa Pine Site Index Tables

1A-3

SITE INDEX	CMAI FOR PONDEROSA PINE 100 YR. TABLE (PIPO) 600-MEYER							CMAI FOR LODGEPOLE PINE 100 YR. TABLE (PICO) 520-ALEXANDER			CMAI FOR WESTERN LARCH 50 YR. TABLE (LAOC) 265-SCHMIDT		
	CU.FT./ AC./YR.	CU.M./ HA./YR.	TOTAL AGE	SCRIBNER BD.FT./ AC./YR.	SCRIBNER TOTAL AGE	INTER.1/8" BD.FT./ AC./YR.	INTER.1/8" TOTAL AGE	CU.FT./ AC./YR.	CU.M./ HA./YR.	TOTAL AGE	CU.FT./ AC./YR.	CU.M./ HA./YR.	TOTAL AGE
70	55	3.8	50	172	160	232	130	59	4.1	90	101	7.1	70
71	56	3.9	50	177	160	240	130	60	4.2	90	103	7.2	70
72	58	4.1	50	182	160	247	130	61	4.3	90	105	7.3	70
73	59	4.1	50	188	160	255	130	62	4.3	90	107	7.5	70
74	60	4.2	50	193	160	263	130	63	4.4	90	109	7.6	70
75	62	4.3	50	198	160	270	130	64	4.5	90	111	7.8	70
76	63	4.4	50	203	160	278	130	65	4.5	90	113	7.9	70
77	64	4.5	50	209	160	285	130	66	4.6	90	116	8.1	70
78	65	4.5	50	214	160	293	130	67	4.7	90	118	8.3	70
79	67	4.7	50	219	160	300	130	68	4.8	90	120	8.4	70
80	69	4.8	40	225	150	313	110	69	4.8	90	122	8.5	70
81	70	4.9	40	232	150	321	110	70	4.9	90			
82	72	5.0	40	238	150	330	110	71	5.0	90			
83	74	5.2	40	245	150	339	110	72	5.0	90			
84	75	5.2	40	252	150	347	110	73	5.1	90			
85	77	5.4	40	258	150	356	110	74	5.2	90			
86	78	5.5	40	265	150	365	110	75	5.2	90			
87	80	5.6	40	271	150	373	110	76	5.3	90			
88	82	5.7	40	278	150	382	110	77	5.4	90			
89	83	5.8	40	284	150	391	110	78	5.5	90			
90	85	5.9	40	292	130	403	100	79	5.5	90			
91	87	6.1	40	300	130	413	100	80	5.6	90			
92	88	6.2	40	308	130	423	100	81	5.7	90			
93	90	6.3	40	316	130	433	100	82	5.7	90			
94	92	6.4	40	324	130	443	100	83	5.8	90			
95	94	6.6	40	332	130	453	100	84	5.9	90			
96	96	6.7	40	340	130	463	100	85	5.9	90			
97	97	6.8	40	348	130	473	100	86	6.0	90			
98	99	6.9	40	356	130	483	100	87	6.1	90			
99	101	7.1	40	364	130	493	100	88	6.2	90			
100	102	7.1	40	372	120	507	90	89	6.2	90			
101	104	7.3	40	381	120	519	90	90	6.3	90			
102	106	7.4	40	390	120	530	90	91	6.4	90			
103	108	7.6	40	399	120	542	90	92	6.4	90			
104	110	7.7	40	408	120	554	90	93	6.5	90			
105	112	7.8	40	417	120	566	90	94	6.6	90			
106	114	8.0	40	426	120	578	90	95	6.6	90			
107	116	8.1	40	435	120	590	90	96	6.7	90			
108	118	8.3	40	444	120	602	90	97	6.8	90			
109	120	8.4	40	453	120	614	90	98	6.9	90			

WITZEL

IA-4

SITE INDEX	CMAI FOR PONDEROSA PINE 100 YR. TABLE (PIPO) 600-MEYER CU.FT./ AC./YR.	CU.M./ HA./YR.	TOTAL AGE	SCRIBNER BD.FT./ AC./YR.	TOTAL AGE	INTER.1/8" BD.FT./ AC./YR.	TOTAL AGE	CMAI FOR LODGEPOLE PINE 100 YR. TABLE (PICO) 520-ALEXANDER CU.FT./ AC./YR.	CU.M./ HA./YR.	TOTAL AGE
110	122	8.5	40	462	110	626	80	99	6.9	90
111	124	8.7	40	473	110	641	80	100	7.0	90
112	126	8.8	40	484	110	657	80	101	7.1	90
113	128	9.0	40	495	110	672	80	102	7.1	90
114	130	9.1	40	506	110	687	80	103	7.2	90
115	132	9.2	40	517	110	702	80	104	7.3	90
116	134	9.4	40	528	110	717	80	105	7.3	90
117	136	9.5	40	539	110	732	80	106	7.4	90
118	137	9.6	40	550	110	747	80	107	7.5	90
119	139	9.7	40	561	110	762	80	108	7.6	90
120	141	9.9	40	572	110	776	70	109	7.6	90
121	144	10.1	40	584	110	793	70			
122	146	10.2	40	597	110	810	70			
123	149	10.4	40	610	110	827	70			
124	151	10.7	40	622	110	844	70			
125	154	10.8	40	635	110	861	70			
126	156	10.9	40	647	110	879	70			
127	159	11.1	40	660	110	896	70			
128	161	11.3	40	672	110	913	70			
129	164	11.5	40	685	110	930	70			
130	166	11.6	40	700	100	947	70			
131	168	11.7	40	714	100	964	70			
132	170	11.9	40	729	100	981	70			
133	173	12.1	40	743	100	998	70			
134	175	12.2	40	758	100	1015	70			
135	177	12.4	40	772	100	1031	70			
136	179	12.5	40	786	100	1048	70			
137	181	12.7	40	801	100	1065	70			
138	183	12.8	40	815	100	1082	70			
139	185	12.9	40	830	100	1099	70			
140	188	13.1	40	844	100	1116	70			
141	190	13.3	40	859	100	1133	70			
142	192	13.4	40	873	100	1150	70			
143	194	13.6	40	888	100	1168	70			
144	197	13.8	40	903	100	1185	70			
145	199	13.9	40	918	100	1202	70			
146	201	14.1	40	932	100	1219	70			
147	203	14.2	40	947	100	1237	70			
148	205	14.3	40	962	100	1254	70			
149	208	14.5	40	976	100	1271	70			

HAZELAIR

PHILOMATH

14.5