Forest Seedling Planting in Washington State

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Abstract

Washington State is geologically and climatically diverse, with a warm, wet climate on the west side of the Cascade Mountain Range and a dry climate with cold winters and hot summers on the east side. This diversity has allowed much of The Evergreen State to become heavily forested with a variety of conifer species. In Washington, which has a long history of timber harvesting and reforestation, the first forest seedling nursery was built in 1911. Since the early 1990s, the total annual harvest volume has trended downward, resulting in declining numbers of seedlings being grown and planted. A current survey of nurseries in the region estimates that an average of 52 million seedlings are planted in Washington State each year.

Washington has 18 million acres (7.3 million hectares) of unreserved timber land, with 48 percent in Federal Government or other government ownership. In addition, 3.3 million acres (1.3 million hectares) of reserved forest land are located in wilderness areas and national parks.

With the wide variation in forested elevation and precipitation, numerous species are used for reforestation, each with considerable genetic variation to reflect local adaptation to the range of growing conditions. Consequently, one size does not fit all, and foresters use a variety of species, seed zones, and stock types to accomplish the objective of successful reforestation.

Figure 1. The Cascade Mountain Range is a prominent feature of Washington and divides the State into eastside and westside. (Photo source: John Trobaugh, WA DNR).

Geographic Variation

In Washington, tremendous geographic variation in forested elevations range from sea level to more than 9,000 ft (2,740 m). The dominant feature is the Cascade Mountain Range (figure 1), which runs north and south through the State and includes the volcanic peaks of Mt. Baker, Mt. St. Helens, Mt. Adams, and Mt. Rainier (the State's highest point at 14,410 ft [4,392 m]). The average statewide elevation is 1,700 ft (518 m).

Washington is divided into eight distinct geographic provinces (figure 2). In general terms, however, the State is divided into the westside and the eastside of the Cascade Mountain Range.

Soil parent material is very complex in the Cascade Mountain Range due to the uplifting and folding of the mountains, mountain glaciations, and volcanic deposits of lava, ash, and pumice. The Coast Range is primarily uplifted ocean floor sandstone with intrusions of basalts. The last continental glacier from the Cordilleran Ice Sheet came down the Puget Trough as far south as Olympia, and at its maximum Seattle was covered by 2,000 ft (610 m) of glacial ice (U.S. Department of the Interior 2011).

Climatic Variation

West of the Cascade Mountain Range

Western Washington has a wet, marine climate, which is mild for its latitude due to the presence of the warm, North Pacific,

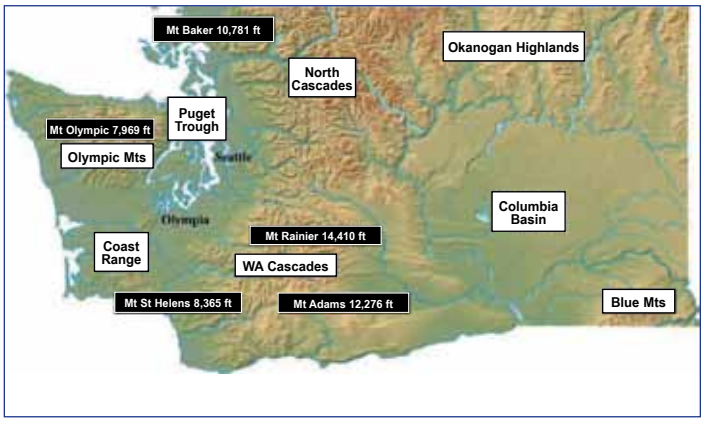

Figure 2. Washington State's eight geographic provinces and five notable mountains. The Cascade Mountain Range runs north and south through the middle of the State.

offshore ocean current. The region has frequent cloud cover, considerable fog, and long-lasting drizzle. Weeks, or even months, may pass without a clear day. Moss grows not only on the north side of trees, but on roofs, lawns, rocks, and just about everywhere. The west side of the Olympic Peninsula receives as much as 150 to 170 in (380 to 430 cm) of precipitation annually, making it the wettest area of the 48 contiguous States and home to the Olympic temperate rain forest (figure 3). The west slope of the Cascade Mountain Range receives some of the heaviest annual snowfall in the country, with some places receiving more than 200 in (500 cm) of wet, heavy snow. Summer is the sunniest season and usually very dry.

In western Washington, the planting season for forestry seedlings is December through March, depending on the snow line elevation. Ideal planting conditions are 34 °F (1 °C) and 100 percent humidity, which are normal conditions for the winter months. Weather, however, combined with steep, mountainous terrain can present some challenging planting conditions (figure 4).

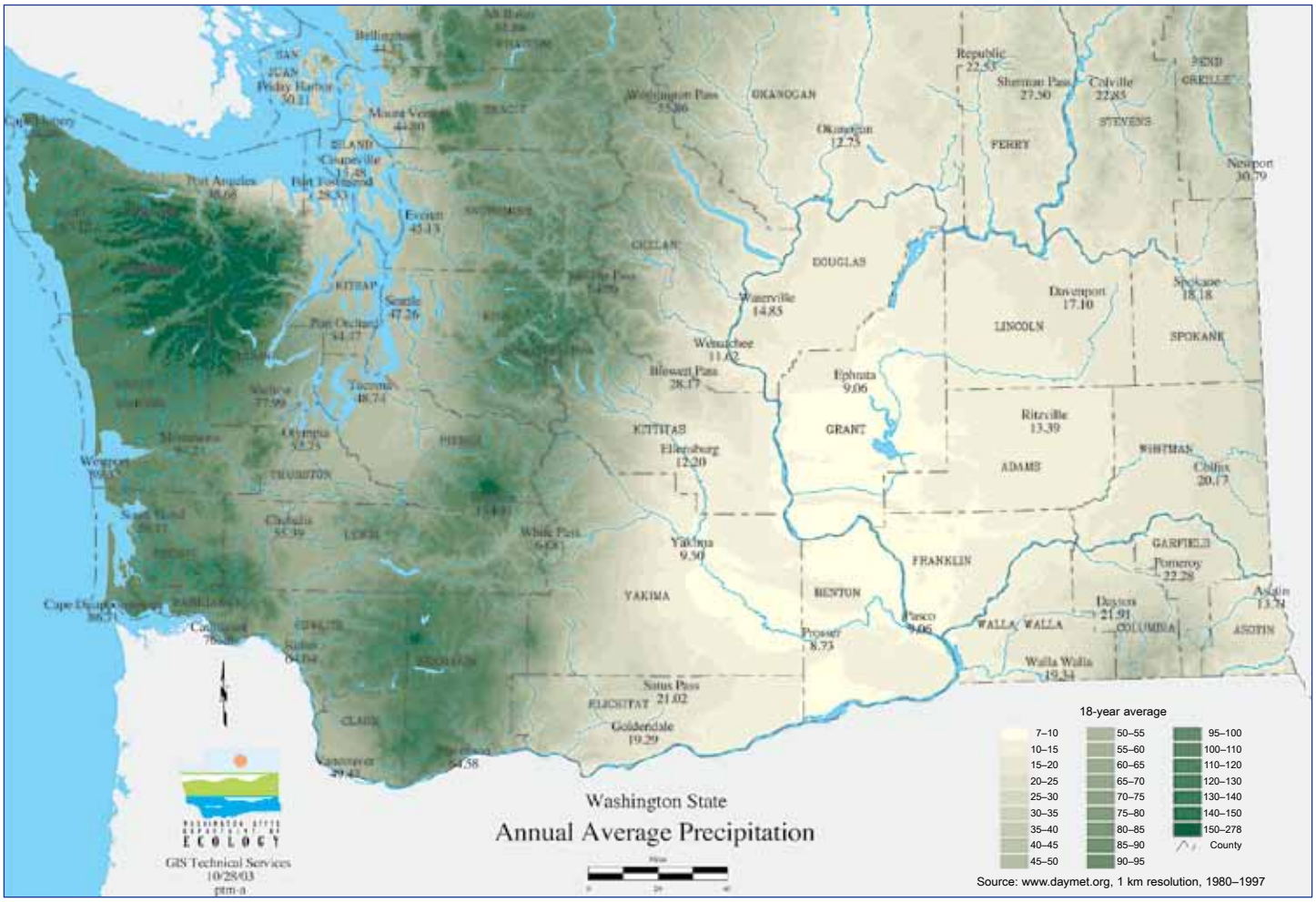

Figure 3. Washington State average annual precipitation. (Source: Washington State Department of Ecology 2011).

Figure 4. Tree planting in the steep foggy conditions of western Washington (left). A member of the planting crew carries two bags of seedlings to tree planters (right). Each bag contains about 150 seedlings and weighs about 50 lbs (23 kg). (Photo source: Chris Rasor, WA DNR 2008).

East of the Cascade Mountain Range

A dry climate prevails east of the Cascade Mountain Range with cold winters and hot summers. In the rain shadow east of the Cascade Mountain Range, the annual precipitation can be as low as 9 in (23 cm) (figure 3), with most of that falling as winter snow.

In eastern Washington, given the cold, snowy winters, the planting season starts in the spring as soon as crews can access the sites. Patches of snow scattered throughout the planting unit may be the only moisture the seedlings will have to establish new root growth and survive the first year after outplanting.

Land Area and Ownership

Washington State encompasses 45.6 million acres (18.5 million hectares) (18th largest State in the United States), with 42.6 million acres (17.2 million hectares) of land area and 3.0 million acres (1.2 million hectares) covered by water. Of the total land area, 43.4 percent is considered unreserved (not withheld from harvest by statute) timber land (capable of growing 20 ft^3 per acre per yr [1.4 m^3 per hectare per yr] mean annual increment). Much of eastern Washington is agricultural, with 2.3 million acres (809,400 hectares) of wheat, 395,900 acres (160,220 hectares) of apples, 31,000 acres (12,546 hectares) of grapes, and 29,000 acres (11,736 hectares) of cherries (figure 5).

Of the 18.3 million acres (7.4 million hectares) of unreserved timber land in Washington, 34 percent is Federal land (figure 6), composed primarily of national forests (Olympic, Gifford Pinchot, Okanogan-Wenatchee, Mount Baker-Snoqualmie, and Colville). In addition, 3.3 million acres (1.3 million hectares) are reserved forest land (withheld from harvest by statute), composed primarily of wilderness areas and national parks (Olympic, Mount Rainier, and North Cascades).

Corporations and other private landowners own 52 percent (9,580,000 acres [3,877,000 hectares]) of timber land in Washington State (figure 6). Most of the privately owned lands are west of the Cascade Mountain Range, low elevation, and very productive.

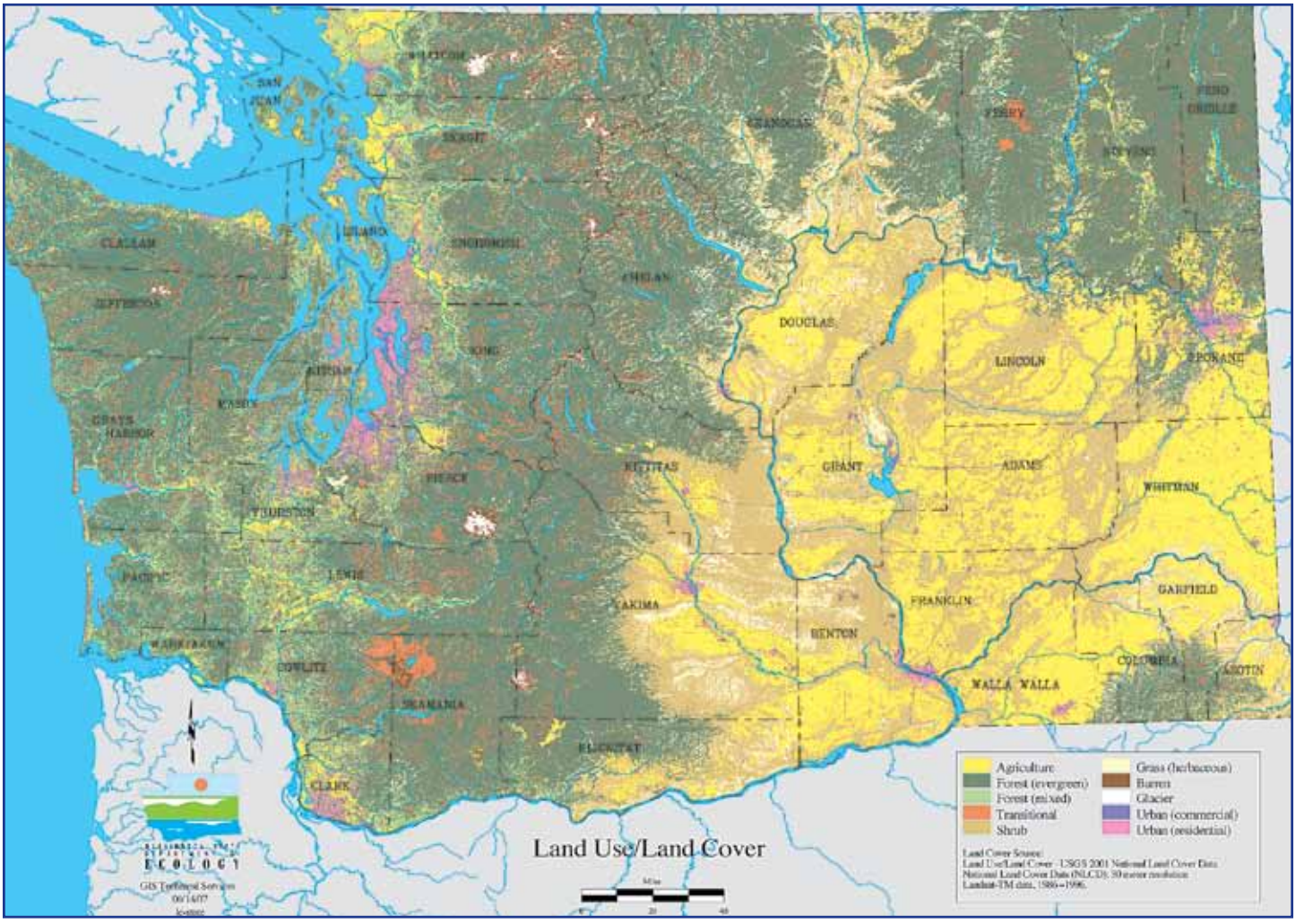

Figure 5. Washington State land use/land cover. (Source: Washington State Department of Ecology 2011).

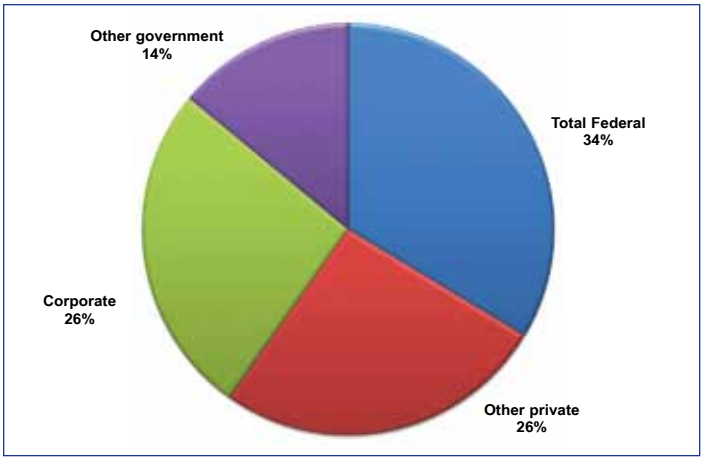

Figure 6. Distribution of unreserved timber land in Washington State, 18,303,000 acres (7,407,224 hectares). (Data source: Campbell and others 2010).

Washington Department of Natural Resources (WA DNR) is responsible for managing approximately 2.1 million acres (0.85 million hectares) of forested trust lands plus leases and permits on 1 million acres (0.4 million hectares) of agriculture lands. Management of trust lands generates about $200 million each year in nontax revenue for public beneficiaries, including kindergarten through 12th grade schools, universities, county governments, and other public institutions.

History of Reforestation in Washington

Some key milestones for reforestation in Washington State, listed by year, are highlighted in the following list.

- **1911:** First forest seedling nursery opened in Washington (U.S. Department of Agriculture [USDA], Forest Service's Wind River Nursery—closed in 1997).
- **1936:** First State nursery, Capitol Forest opened (closed in the 1950s when seedling production was relocated to Webster Forest Nursery).
- **1938:** First industrial nursery (Weyerhaeuser) opened near Snoqualmie Falls, WA. Currently, four industrial nurseries operate in the State along with approximately seven private forest seedling nurseries and dozens of conservation nurseries.
- **1946:** Washington State's first Forest Practices Act required reforestation of harvested lands.
- **1957:** First seedling shipment from WA DNR's, L.T. Mike Webster Forest Nursery, established just south of Olympia. Today, Webster nursery consists of 270 acres (110 hectares) of bareroot ground and 72,000 ft^2 (6,700 m^2) of greenhouses (figure 7).
- **1970s**: Container seedling production began with greenhouses constructed by WA DNR, forestry companies, and private nurseries.

Figure 7. Washington State's Webster Nursery near Olympia produces both container and bareroot seedlings. Top to bottom: seedlings are grown in the greenhouse for outplanting or transplanting, bareroot seedlings during summer growth, and bareroot seedlings during fall frost protection. (Photo source: John Trobaugh, WA DNR).

- **1974:** Forest Practices Act established (amended many times since).
  - Western Washington: Within 3 years of harvest, at least 190 trees per acre (469 per hectare) must be established (healthy trees remaining after first growing season). (Note: common practice is to plant approximately 390 seedlings per acre (964 per hectare), with an expected fifth year survival of 88 percent [Trobaugh 2008]).
  - Eastern Washington: Within 3 years of harvest, at least 150 trees per acre (370 per hectare) must be established.
- **1990s:** Northwest Forest Plan was adopted for 25 million acres (10 million hectares) administered by the USDA Forest Service and the Bureau of Land Management within the range of the spotted owl.
- **1999:** Washington Forests & Fish Law passed; regulates habitat along 60,000 mi (96,558 km) of streams in the State. Riparian Management Zone can be up to 200 ft (61 m) on each side of streams, lakes, and ponds that are used by fish, amphibians, wildlife, and for drinking water (WA DNR 2009).

Timber Harvest and Seedling Production

Currently, no established reporting method tracks how many seedlings are planted annually in Washington State. For this article, timber harvest volumes are used as a rough surrogate for the number of seedlings planted for reforestation along with a survey sent to 19 forest seedling nurseries in the region regarding the average number of seedlings grown for Washington State during the past 5 years. Variations in the volume harvested per acre, along with the type of harvest (clearcut versus partial harvest), result in an element of uncertainty for estimating seedling planting, but given the lack of other data sources, it is the closest approximation that can be made. From 1965 to 1989, considerable market fluctuations occurred, but annual harvest volume averaged approximately 6.5 billion board ft (15.3 million m^3) (figure 8). Since 1990, harvest volumes have declined to a record low of 2.2 billion board ft (5.2 million m^3) in 2009 (figure 8). Because of demand from China, total harvest volume increased in 2010 to 2.7 billion board ft (6.4 million m^3) (figure 8). To put this production level into national perspective, in 2004 Washington State harvested 3.8 billion board ft and ranked ninth nationwide for total value of Forest Products Shipments ($9,655,591,000), with 51 percent paper and 49 percent wood products (U.S. Census Bureau 2006).

Figure 8. Timber harvest in Washington State: 1965–2010 (Data source: WA DNR 2010).

A reasonable assumption is that the number of seedlings planted for reforestation has followed trends similar to timber harvest rates. Of the largest nurseries in the region, 11 responded to a 2011 survey, and reported that approximately 52 million seedlings were planted each year. Similar to the harvest trends, this seedling planting level was down from the 85 million seedlings reported as planted in 1997 (Moulton 1999).

Forest Health

In eastern Washington, widespread damage, primarily from insects, has caused cumulative tree mortality and a predicted risk of mortality to 2.8 million acres (1.1 million hectares). In November 2011, WA DNR initiated a tier-two forest health hazard warning (WA DNR 2011a). The amount of acreage that was damaged by disease and insects during the past decade is estimated to be 150 percent greater than the amount damaged in the 1990s, and 200 percent greater than the amount damaged in the 1980s (WA DNR 2011b). Additional information concerning the health of Washington's forests can be found on the WA DNR Forest Health Program Web site (WA DNR 2011c).

Forest Types and Seed Zones

Forests in The Evergreen State are dominated by conifers (table 1). Consequently, most of the seedlings that are planted are conifers. The WA DNR's Webster Forest Nursery grows 73 percent Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco), 7 percent western redcedar (*Thuja plicata* Donn ex D. Don), 6 percent ponderosa pine (*Pinus ponderosa* Dougl. ex Laws), and 5 percent western larch (*Larix occidentalis* Nutt.). The other 9 percent consists of 11 relatively minor species.

Because of the large geographic and climatic variation, large genetic variations also exist within most species. For example, Douglas-fir has 16 seed zones, which are further divided by elevation bands every 1,000 ft (305 m) on the westside of the Cascade Mountain Range and every 700 ft (213 m) on the eastside of the Cascade Mountain Range (figure 9) (Randall and Berrang 2002).

Seedling Stock Types

During the early years of seedling production in Washington, Douglas-fir 2 + 0 seedlings (2 years in the seed bed plus 0 years in the transplant bed) were the standard stock type grown (figure 10). When larger seedlings were needed, 1 + 2 or 2 + 1 seedlings were grown, but they were the exception. In those days, large contiguous clearcuts with hot broadcast burns were the standard harvest and site preparation methods, and 2 + 0 seedlings were very successful. Today, planting sites are not broadcast burned, resulting in more slash and brush (figure 4) and a preference by reforestation foresters for larger 1 + 1 (1 year in a bareroot seed bed plus 1 year in the transplant bed) and plug + 1 (started as a plug seedling plus 1 year in a transplant bed) seedlings (figure 10).

Table 1. Forest types in Washington State.

Forest type	Acres	Percent
Douglas-fir	8,658,000	39.00
Fir/spruce/mountain hemlock	3,992,000	18.00
Western hemlock/sitka spruce	3,300,000	15.00
Ponderosa pine	2,069,000	9.00
Lodgepole pine	651,000	3.00
Western larch	318,000	1.00
Western white pine	11,000	0.05
Other softwoods	186,000	1.00
Alder/maple	1,905,000	9.00
Other hardwoods	673,000	3.00
Nonstocked	625,000	3.00
Total	**22,388,000**	**100.00**

(Source: Campbell, Waddell, and Gray 2010).

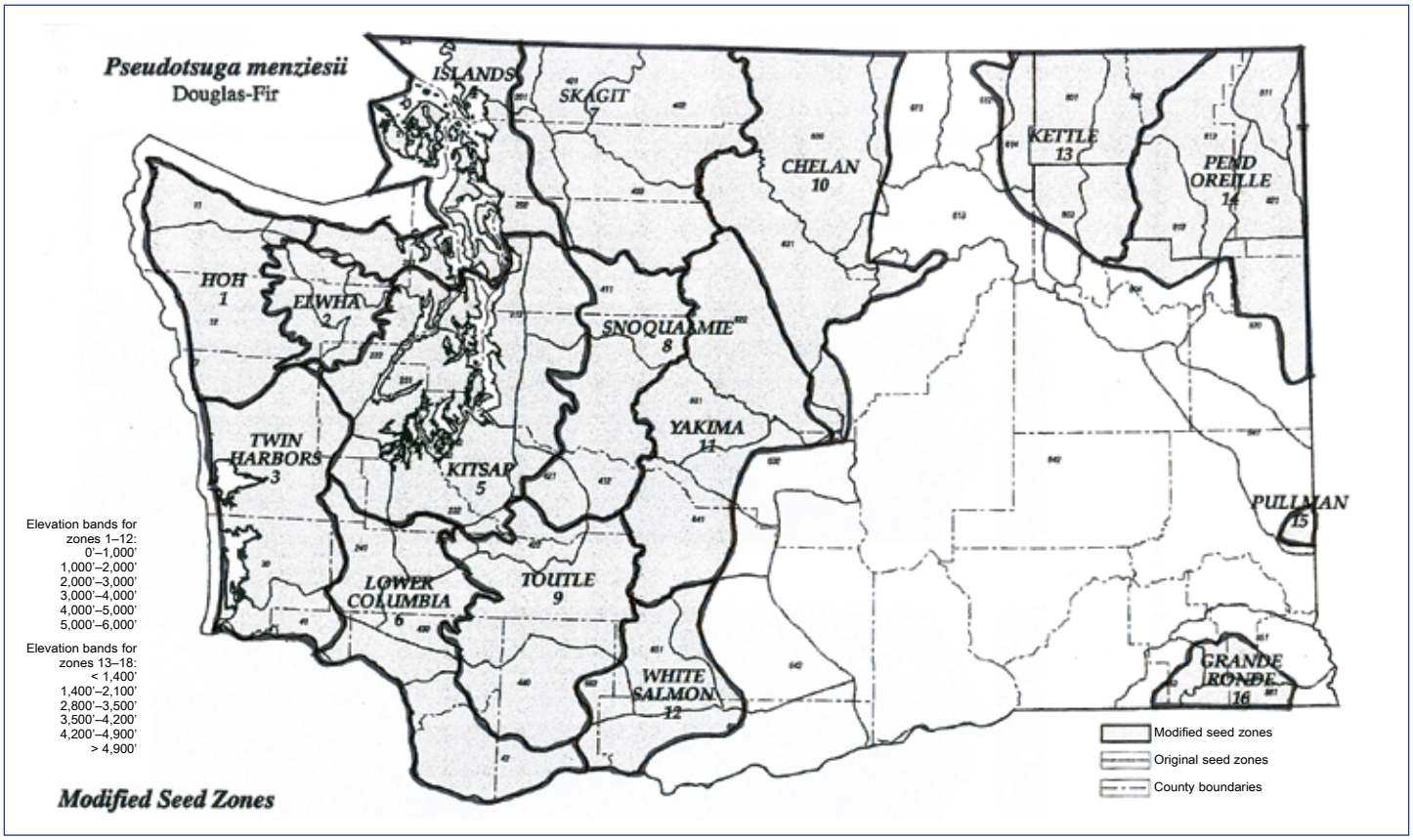

Figure 9. Seed transfer zones for Douglas-fir within Washington State. (Source: Randall and Berrang 2002).

In the 1970s, container (plug) seedlings became a popular choice in Washington, with several organizations building greenhouse facilities to cultivate the plug seedlings. Early production focused on S-2, S-4, S-6, and S-8 stock types (seedlings grown in Styroblocks™ with 2, 4, 6, or 8 in^3 cavities [33, 36, 98, or 131 cm^3]) (figure 11). Use of the Styroblock™ container system (Beaver Plastics Ltd, distributed in the United States by Stuewe and Sons, Inc.) became the standard for forest container nurseries in the Pacific Northwest. Some species such as Sitka spruce (*Picea sitchensis* [Bong.] Carrière), western redcedar, and western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) can have 200,000 to 400,000 seeds per lb (90,909 to 181,818 seeds per kg) and are best started in containers.

Improved cultural treatments during the past few decades have led to the ability to produce increasingly larger seedlings. Today, a Douglas-fir 1 + 1 seedling is as large as a 1 + 2 or 2 + 1 seedling was in the past. The demand for larger seedlings has increased and 1 + 1 and plug + 1 are currently the preferred bareroot stock type seedlings that are used for reforestation in Washington State (figures 10 and 12). Demand for larger container seedlings has also increased with S-10, S-15, and S-20 seedlings being the most common stock types grown for outplanting on the westside of the Cascade Mountain Range (figures 11 and 12) (Briggs and Trobaugh 2001).

Figure 10. Douglas-fir bareroot stock types. From left to right: 2 + 0 (2 years in a seed bed plus 0 years in a transplant bed), 1 + 1 (1 year in a bareroot seed bed plus 1 year in a transplant bed), and plug + 1 (started as a container ["plug"] seedling plus 1 year in a transplant bed). (Photo source: John Trobaugh, WA DNR).

Figure 11. Douglas-fir container stock types. From left to right: S-4 (4 cubic inch root plug, 313A), S-10 (10 cubic inch root plug, 415D), and S-20 (20 cubic inch root plug, 615A). (Photo source: John Trobaugh, WA DNR).

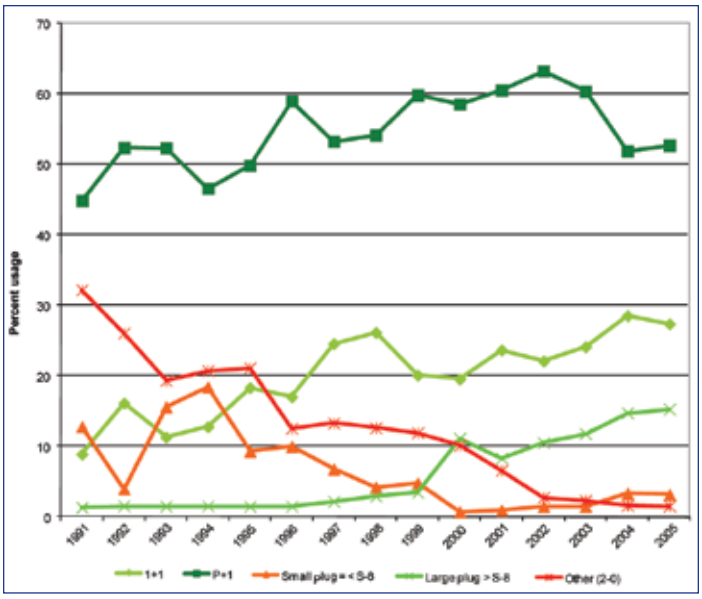

Figure 12. Douglas-fir stock type trends (1991–2005) for large forest landowners in western Washington and Oregon. (Data source: Briggs and Trobaugh 2001).

Because of the variety of site conditions, tree species, and potential browse damage from deer and elk, reforestation foresters use a variety of stock types to accomplish the objective of successful reforestation within 3 years of a harvest. Container seedlings are preferred on harsh, dry, rocky sites (especially on the eastside of the Cascade Mountain Range), while a large, woody 1 + 1 or P + 1 seedling is preferred on sites where a high level of animal damage is expected.

Washington Tree Planting Into the Future

Washington State has some of the most productive forests in the world, grows a high-value product, and has a long, rich history of forestry. Despite many, often competing interests, forestry continues to be a vital part of the State's economy. In 2009, the forest seedling industry experienced a crash in the demand for seedlings and surplus seedlings were destroyed by the millions. Since then, the high demand for wood in Asia has led to increased timber harvesting. As a result, seedling demand in Washington is up and, for the second year in a row, most nurseries are sold out of seedlings. Washington is well situated to provide wood for both the U.S. and Pacific Rim markets. For the foreseeable future, reforestation in Washington will continue to be a strong and green industry.

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References

Briggs, D.; Trobaugh, J. 2001. Management practices on Pacific Northwest west-side industrial forest lands, 1991–2000: with projections to 2005. Stand Management Cooperative Working Paper No. 2. Seattle: University of Washington. 72 p. http://www.cfr.washington.edu/research.smc/research/working%20paper%202.pdf. (December 2011).

Campbell, S.; Waddell, K.; Gray, A. 2010. Washington's forest resources, 2002–2006: 5-year forest inventory and analysis report. General Technical Report PNW-GTR-800. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 189 p.

Moulton, R.J. 1999. Tree planting in the United States—1997. Tree Planters' Notes. 49(1): 5–15.

Randall, W.K.; Berrang, P. 2002. Washington tree seed transfer zones. Olympia: Washington Department of Natural Resources. 84 p. http://www.dnr.wa.gov/Publications/lm_wfn_seedzone_book.pdf. (December 2011).

Trobaugh, J. 2008. Reforestation planting densities in the Northwest. Northwest Woodlands. 24(4): 20–22.

U.S. Census Bureau. 2006. Geographic area statistics: 2004, annual survey of manufacturers. M04(AS)-3. 74 p. www.census.gov/prod/ec02/am0431as1.pdf. (December 2011).

U.S. Department of the Interior, U.S. Geological Survey. 2011. Glaciations, ice sheets, and glacial lakes. http://vulcan.wr.usgs.gov/Glossary/Glaciers/IceSheets/. (December 2011).

Washington State Department of Ecology. 2011. Washington State maps. http://www.ecy.wa.gov/services/gis/maps/state/state.htm. (December 2011).

Washington State Department of Natural Resources (WA DNR). 2009. Forest practices illustrated: a simplified guide to forest practices rules in Washington State. http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_fpi.aspx. (December 2011).

Washington State Department of Natural Resources (WA DNR). 2010. Washington State timber harvest reports. http://www.dnr.wa.gov/BusinessPermits/Topics/EconomicReports/Pages/obe_washington_timber_harvest_reports.aspx. (March 2012).

Washington State Department of Natural Resources (WA DNR). 2011a. Commissioner Goldmark initiates tier two forest health hazard warning. Press release, November 14, 2011. http://www.dnr.wa.gov/ResearchScience/News/Pages/2011_11_14_foresthealth.aspx. (December 2011).

Washington State Department of Natural Resources (WA DNR). 2011b. Goldmark alarmed by the health of forests: testifies before legislative committee. Ear to the Ground, December 2, 2011. http://washingtondnr.wordpress.com/2011/12/02/goldmark-alarmed-by-the-health-of-forests-testifies-before-legislative-committee/. (December 2011).

Washington State Department of Natural Resources (WA DNR). 2011c. Forest health program. http://www.dnr.wa.gov/ResearchScience/Topics/ForestHealthEcology/Pages/rp_foresthealth.aspx. (December 2011).