FIELD NOTE

Growth and Survival of Port-Orford-Cedar Families on Three Sites on the South Oregon Coast

Constance A. Harrington, Peter J. Gould, and Richard A. Sniezko

ABSTRACT

Port-Orford-cedar is of interest to ecologists and foresters, but little information is available on its growth, its genetic variation, or the field performance of families selected for resistance to root disease. Survival, damaging agents, and growth were evaluated for nine families at three outplanting sites in south coastal Oregon. Survival was excellent on two sites. Family differences were observed in growth rates, foliage dieback, and tendency to form multiple stems after browsing. Mean tree height 8 growing seasons after planting was 2.6 m; the heights of the tallest trees on one site were >5.5 m.

Keywords: *Chamaecyparis lawsoniana, Phytophthora lateralis,* multiple stems, browsing damage, foliage disease

Port-Orford-cedar (*Chamaecyparis lawsoniana*) has a narrow native range (in northern California and southern Oregon; Zobel 1990), but as an ornamental, it has been widely planted on several continents. The wood of the species is quite valuable, but introduction of a nonnative root rot, *Phytophthora lateralis*, has resulted in substantial mortality within its native range, and many managers have considered it not to be a suitable candidate for reforestation because of this disease. The US Forest Service and Bureau of Land Management have established a program at the Dorena Genetic Resource Center (Dorena GRC) to screen for genetic resistance to Port-Orford-cedar root disease; this program oversees breeding to produce resistant seed for reforestation and restoration (Sniezko 2006). In 2002, three outplanting sites were established by the Dorena GRC with forest industry cooperators to evaluate the growth and disease resistance of 9 families from this program. This report covers growth, survival, and damage for those sites through plantation age 8.

Materials and Methods

Seed from the disease resistance program at Dorena GRC was used in this study. The parent trees originated from natural stands and are represented as rooted cuttings in orchards or clone banks at Dorena GRC. Some seedlots used in this trial were full siblings from controlled crosses, and others were the result of wind pollination among many parents in the containerized orchards. The nine seedlots (families) were chosen to cover the full range of mortality (from 0 to 100%), which resulted from a seedling root-dip test using *P. lateralis* in a greenhouse trial (R. Sniezko, unpublished results). Six families had maternal parents from low elevation (<800 m) areas in the south Oregon coast (JR13 Breeding Zones 110, 125, and 210; see Dorena GRC 2006 for breeding zones), and three families had maternal parents from higher elevation (>800 or >1,200 m) areas more inland in southern Oregon or northern California (JR13 Breeding Zones 350, 440, and 450). Seedlings were grown in 164-mL containers at Dorena GRC for 1 year.

The outplanting locations (Table 1) were in Coos County, Oregon (one site 8 km northeast of Bandon), and Curry County, Oregon (two sites 16–22 km east of Sixes). The surface soil texture at all locations was silt loam. Port-Orford-cedar had been present in the previous stands at all sites, but root disease had not been documented. Port-Orford-cedar root disease spreads by movement of spores in water or soil (attached to animal feet or equipment) or by transport of diseased stock. At each outplanting location, four blocks were established. Families were randomly assigned to rows in each block, with 8–10 seedlings per family in each block. The planting locations were viewed prior to planting; areas considered unsuitable for planting (e.g., old skid road or large stump) were skipped, and the row was extended as necessary to plant all the seedlings. Site preparation treatments were applied prior to planting; photographs taken shortly after planting provided evidence that competing vegetation was well controlled at all sites at that time. Disease-free seedlings were outplanted by hand in spring 2002.

After outplanting, the sites were visited periodically and surveyed for mortality (causes ascertained in most cases by pathologists) and other damage. Trees were measured for height 4 growing seasons after outplanting and for height and diameter (at 1.3 m) 8 growing seasons after outplanting.

Results

Survival and Damage

Survival was excellent at the Tent Prairie (99%) and Coquille River (97%) outplanting sites, with most trees in all families surviving to the 8-year evaluation. Survival was much lower (60%) at the

Manuscript received April 11, 2011, accepted August 3, 2011. http://dx.doi.org/10.5849/wjaf.11-015.

Constance A. Harrington (charrington@fs.fed.us), and Peter J. Gould (pgould@fs.fed.us), US Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3625 93rd Avenue SW, Olympia, WA 98512-9193. Peter J. Gould and Richard A. Sniezko (rsniezko@fs.fed.us), US Forest Service, Dorena Genetic Resource Center, 34963 Shoreview Road, Cottage Grove, OR 97424. *We thank the Menasha Corporation, Moore Mill Company, and Plum Creek Timber Company for installing the plantings and allowing access for ongoing assessments and Oregon State University for their ongoing assistance in the pathology evaluations and the resistance breeding work. We also thank the other employees and volunteers who have participated in the assessments. Readers interested in participating in future trials of Port-Orford-cedar should contact Richard Sniezko.*

This article uses metric units; the applicable conversion factors are: centimeters (cm): 1 cm = 0.39 in.; meters (m): 1 m = 3.3 ft; kilometers (km): 1 km = 0.6 mi; milliliter (mL): 1 mL = 0.061 in.^{3} (dry), = 0.27 fluid dram (liquid).

Table 1. Site information for 2002 Port-Orford-cedar outplantings.

Site name	Cooperator	Soil mapping unit[a]	Drainage class	Elevation (m)	Slope	Browse control	Mean minimum temperature, coldest month[b]	Mean maximum temperature, warmest month[b]	Mean April–September precipitation[b] (mm)
							(°C)		
Tent Prairie	Moore Mill	Etelka-Whobrey-Remote	Moderately well	577	10%–20%	Vexar tubes	1.8	22.6	347
Coquille River	Menasha	Templeton	Well	20	Mostly flat	Fence	3.1	21.9	326
Avery Ranch	Plum Creek	McCurdy-Wintley complex	Moderately well	153	Mostly flat	Fence	2.4	24.9	334

[a] Based on USDA Natural Resource Conservation Service 2011.
[b] Climate information from the Rocky Mountain Research Station Climate Model 2011.

Table 2. Mean (with standard deviation), minimum (min), and maximum (max) heights and diameters of Port-Orford-cedar families 8 years after outplanting at three sites.

	Height (m)									dbh (cm)								
	Tent Prairie			Coquille River			Avery Ranch			Tent Prairie			Coquille River			Avery Ranch		
Family	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max
15	2.1 (0.38)	1.1	2.9	2.0 (0.38)	1.2	3.9	3.6 (0.42)	1.5	4.2	2.1 (1.19)	0.2	4.6	1.6 (1.36)	0.1	5.5	4.6 (1.77)	0.1	7.5
17	2.4 (0.39)	0.8	3.4	2.6 (0.40)	0.8	4.3	4.3 (0.42)	3.0	6.0	3.0 (1.56)	0.3	6.0	2.6 (1.80)	0.1	7.5	6.5 (2.40)	1.8	11.6
34	2.2 (0.37)	0.9	2.9	2.6 (0.41)	0.8	4.3	3.9 (0.43)	2.2	4.9	2.3 (1.29)	0.6	5.0	2.7 (1.96)	0.1	7.9	5.0 (2.42)	1.3	9.6
36	2.7 (0.37)	1.2	3.6	2.4 (0.40)	1.1	4.9	3.8 (0.44)	2.2	4.8	3.8 (1.47)	1.1	8.5	2.4 (1.92)	0.2	9.2	5.1 (2.33)	0.1	8.4
39	1.9 (0.37)	0.8	2.6	2.7 (0.39)	1.4	4.0	3.7 (0.43)	2.9	4.7	1.4 (1.03)	0.2	4.1	2.8 (1.37)	0.3	5.6	5.1 (1.80)	1.5	8.0
41	1.7 (0.38)	0.8	2.5	2.9 (0.39)	1.2	4.2	4.1 (0.51)	2.9	5.2	1.0 (0.96)	0.1	3.0	3.1 (1.57)	0.4	6.5	5.9 (2.63)	1.9	10.8
42	2.2 (0.37)	1.3	3.0	2.3 (0.39)	0.7	3.3	3.5 (0.42)	2.3	4.7	2.4 (1.29)	0.1	4.4	2.1 (1.19)	0.1	4.8	4.5 (2.74)	0.4	9.9
43	2.2 (0.38)	0.7	2.8	2.4 (0.39)	0.8	4.4	3.9 (0.44)	3.0	5.5	2.5 (1.46)	0.2	5.8	2.3 (1.69)	0.2	8.4	6.3 (2.49)	2.9	11.3
44	2.0 (0.39)	0.6	3.2	2.0 (0.40)	0.9	3.8	2.8 (0.48)	1.0	4.1	2.0 (1.66)	0.2	6.6	1.6 (1.78)	0.1	6.6	3.1 (1.77)	0.2	6.5

Avery Ranch site. Some trees were dead by the end of the first or second growing season; additional mortality was coded at each visit to Avery Ranch. Approximately 40% of the trees at Avery Ranch had vole damage, and voles were the primary mortality agent at this site. Very few tree deaths were attributed to *P. lateralis*. Evidence of bark beetle activity (probably *Phleosinus* spp.) was also observed on some trees. *Stigmina* foliar blight and cypress or *Seiridum* canker were each observed on one tree.

The sites differed in the major damaging agents. The unfenced Tent Prairie site was heavily browsed by deer and elk in early years (>90% of trees were coded as browsed 4 years after outplanting); most of the formerly browsed trees recovered well, and their terminals are now above likely height for future browsing. Past browsing resulted in 23% of the trees forked below 1.3 m and about 10% with two or more leaders at the 8-year measurement. Forking occurred in some trees in all families but was most prevalent on families 17 (50%) and 42 (37%). Coquille River had 31% of the surviving trees with foliage dieback at the 8-year measurement; this condition appeared on only 11% of trees in families 17 and 41 and on ≥60% of surviving trees in families 42, 43, and 46 (these three families were from the more inland breeding zones).

Height and Diameter

Individual tree heights 4 growing seasons after planting ranged from 45 to 305 cm (Table 2). Heights after 8 growing seasons ranged from 55 to 600 cm. Mean tree height after year 8 (Figure 1) was least at Tent Prairie (2.2 m), intermediate at Coquille River (2.4 m), and greatest at Avery Ranch (3.7 m). Family rankings were generally consistent, especially for the 2 fenced sites. With one exception (family 46), mean height after 8 growing seasons was 2 m or greater for all families at Coquille River and >3.5 m tall at Avery Ranch.

The tallest family at each site was also the one with the greatest diameter at 1.3 m (Table 2). Overall, after 8 growing seasons, the best families at Tent Prairie and Coquille River had mean diameters >3 cm, and the best families at Avery Ranch had diameters >6 cm.

There were not enough representatives of each breeding zone to test for differences in growth between zones. There were three families with the same maternal parent (families 15, 17, and 36); the poorest performer of these three families was 15, which was selfed (fertilized with pollen collected from the same clone). The other family that tended to be a poor performer in height was family 46, whose maternal parent was from a high-elevation (>1,220 m) breeding zone.

Discussion

There is very little information in the literature on Port-Orford-cedar regeneration in a forest setting (as opposed to use as an ornamental), and what has been published has generally been negative or cautionary because of root disease (Zobel 1990), concerns over cold hardiness (Duffield 1956, Hunt and Dimock 1957), or poor survival after outplanting (Kitzmiller 2006). However, foresters and ecologists have become interested in using the species for reforestation to further ecological goals of preserving species diversity (substantial mortality has occurred within its native range) or timber production goals (valuable wood, not susceptible to Swiss needle cast disease). Although several Port-Orford-cedar plantations have been established in recent years, to our knowledge, this is the first report of outplanting performance of multiple families at several sites in the Oregon Coast Range. These outplantings demonstrate our ability to regenerate Port-Orford-cedar. It will take longer than 8 years to evaluate the sensitivity of these outplantings to the full range of damaging agents and to express their full growth potential.

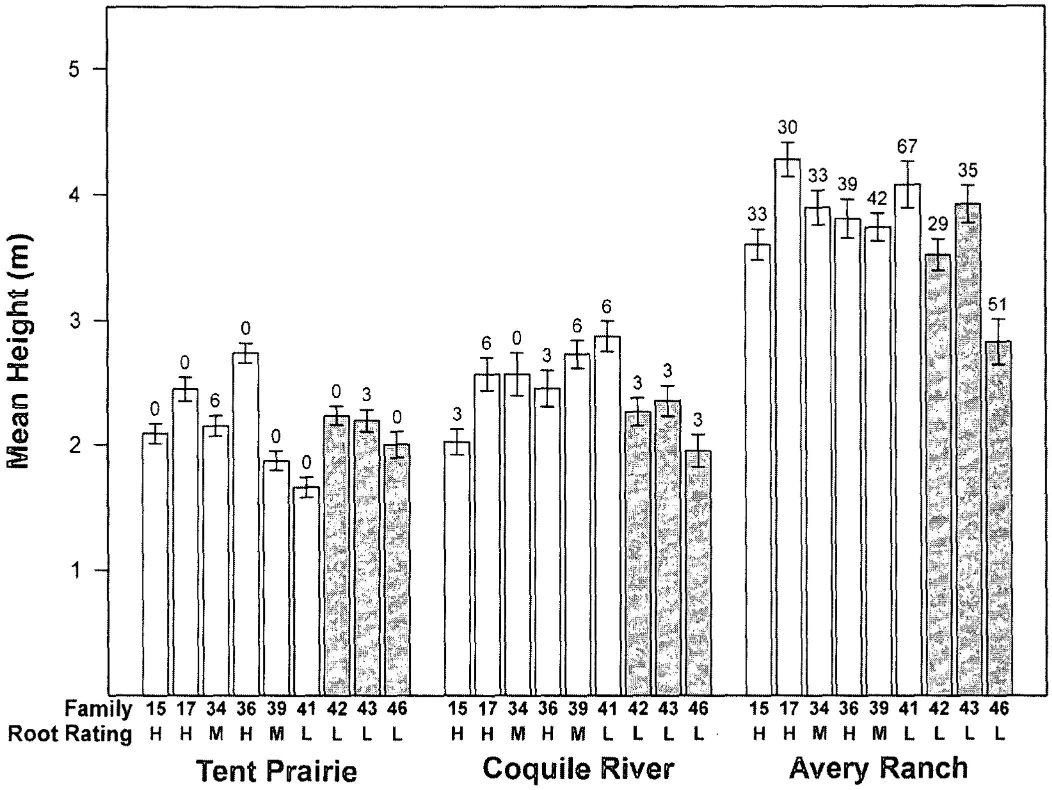

Figure 1. Mean height and standard error for all surviving trees 8 years after outplanting of Port-Orford-cedar families by outplanting site and family. Standard errors were calculated from individual tree values for each site and family. Percentage of mortality is indicated by the number at the top of each bar. Root rating indicates whether the family had high (H), medium (M), or low (L) survival based on a seedling root-dip test with *Phytophthora lateralis*. The shaded bars indicate maternal parents from inland breeding blocks (Dorena Genetic Resource Center 2006).

Some Early Lessons Learned From the Plantings

The species can survive well after outplanting, but it is susceptible to several damaging agents. In previous outplantings in California and Oregon (Kitzmiller 2006), two of five sites were dropped from the study early on because of poor survival associated with lack of vegetation control, and by year 7, survival of the remaining outplantings ranged from 34% to about 77%. Thus, we are encouraged by the high survival rate on two of our sites.

At the Coquille River site, where foliage dieback was common, the three families from more inland sources were much more susceptible than the families from more coastal sources. The foliage dieback observed on nonlocal sources at this coastal site may be important, especially if harvesting boughs is being considered as an option.

At the unfenced Tent Prairie site, families differed substantially in the percentage with forking below 1.3 m, so we would suggest that forking be coded in future evaluations of outplantings. Vole damage was a factor at the Avery Ranch site, so controlling grassy or herbaceous vegetation may be important in getting seedlings established (Duddles and DeCalesta 1992). Animal damage at these sites confounded the usual relationship between good growth and good survival seen when physical factors such as soil moisture are controlling plant responses.

Port-Orford-cedar root disease has not played a major role in mortality to date; therefore, we cannot yet tell whether the rankings of resistance based on seedling root dips will be effective in predicting family resistance in the field until information is available for a longer time period or from more families and sites. It was notable, however, that *P. lateralis* was not a major source of mortality through age 8. On the basis of our results, other outplantings in progress, and general ecophysiological information (e.g., Zobel 1990), we suspect that additional successful outplantings could be made if the following guidelines were followed: obtain seed from the Dorena GRC resistance program, select seedlots from appropriate breeding zones, plant seedlings on sites that are not compacted or poorly drained, and control competing vegetation during establishment.

Literature Cited

DORENA GENETIC RESOURCE CENTER. 2006. *Availability of resistant Port-Orford-Cedar seed.* US For. Serv. Dorena Genetic Resource Center, Pub 303. 8 p. Available online at www.fs.fed.us/r6/dorena/documents/publications/pub303.pdf; last accessed Sept. 27, 2011.

DUDDLES, R.E., AND D.S. DECALESTA. 1992. *Controlling vole damage to conifer seedlings.* Oregon State Univ. Extension Service EC 1256. 6 p.

DUFFIELD, J.W. 1956. *Damage to western Washington forests from November 1955 cold wave.* US For Serv. Res. Note 129. 5 p.

HUNT, J., AND E.J. DIMOCK II. 1957. Port-Orford-cedar: A poor risk for reforestation. US For. Serv. Res. Note 139. 3 p.

KITZMILLER, J.H. 2006. Range-wide genetic variation in Port-Orford-cedar (*Chamaecyparis lawsoniana* [A. Murr.] Parl.) III: Survival and growth in coastal and inland plantations. *J. Sust. For.* 23:1–46.

ROCKY MOUNTAIN RESEARCH STATION CLIMATE MODE. *Research on forest climate change: Potential effects of global warming on forests and plant climate relationships in Western North America and Mexico.* Available online at forest.moscowfsl.wsu.edu/climate/; last accessed Jan. 18, 2011.

SNIEZKO, R.A. 2006. Resistance breeding against nonnative pathogens in forest trees: Current successes in North America. *Can. J. Plant Pathol.* 28:S270–S279.

USDA NATURAL RESOURCE CONSERVATION SERVICE. 2011. *Web soil survey.* Available online at websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx; last accessed Sept. 27, 2011.

ZOBEL, D. 1990. *Chamaecyparis lawsoniana* (A. Murr.) Parl. Port-Orford-cedar. P. 88–96 in *Silvics of North America, volume 1: Conifers,* Burns, R.M., and B.H. Honkala (tech. coords.). USDA Agric. Handb. No. 654.