Survival and Early Growth of Alnus rubra, Eucalyptus macarthurii, E. viminalis, and Populus trichocarpa in the Pacific Northwest

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*Survival, growth, and aboveground biomass production of two Eucalyptus species--*E. viminalis *Lab. and* E. macarthurii *Deane & Maiden—were studied and compared to two native hardwoods—Alnus rubra Bong. and Populus trichocarpa Torr. & Gray--during a 3-yr study on low-elevation glacial till soils in the Pacific Northwest. Height growth and aboveground biomass production were significantly lower for both* Eucalyptus *species throughout the study. Both* Eucalyptus *species suffered from severe frost damage during the winter after the second growing season, resulting in dieback followed by coppicing. Different aspects of survival and growth of fast-growing native and exotic species in relation to short-rotation plantations in the Pacific Northwest are discussed.* Tree Planters' Notes 38(4):27-30; 1987.

Millions of hectares of *Eucalyptus* forests have been planted in many countries around the world (3). Some 700 species of this genus grow under a broad range of environmental conditions. Studies of *Eucalyptus* growth and productivity in the southeast United States were begun about three decades ago. Since then, many *Eucalyptus* species have been planted in a wide range of sites in many areas of the United States.

The southern areas of Florida, Texas, and California have been promising sites, chiefly because of their frost-free climates (9). Both *E. macarthurii* and *E. viminalis* have been considered as promising exotic species for pulpwood sources in the southeastern United States (4).

The Pacific Northwest region of the United States is among several areas in the country where the use of short-rotation plantations of hardwood species for fiber production may become economically feasible in the future. A number of native and exotic species may provide the basis for such projects.

Unlike native conifers, which are characterized by slow juvenile growth, many native hardwood species exhibit rapid early growth. Among the fast-growing native hardwoods, red alder (*Alnus rubra* Bong.) and black cottonwood (*Populus trichocarpa* Torr. & Gray) have been studied for a variety of experimental purposes including biomass production for the past two decades (2, 6, 7).

Other fast-growing hardwoods, including frost-tolerant exotic species, should also be considered for short-rotation purposes; however, their potential in the Pacific Northwest has not been studied previously.

In this study, two frost-tolerant *Eucalyptus* species, *E. viminalis* Lab. and *E. macarthurii* Deane & Maiden, were evaluated for use in short-rotation plantations at low elevation. Their survival, growth, and aboveground biomass production were compared with those of two native fast-growing hardwood species.

Materials and Methods

The study was conducted at the University of Washington's Lee Experimental Forest located in Southern Snohomish County, WA. The elevation is 140 m, precipitation averages 1100 mm per year, with about 300 to 400 mm occurring during the growing season (April-October). The study site was described in detail by Pezeshki and Hinckley (12).

Seeds of *E. viminalis* and *E. macarthurii* were obtained from the North Carolina State University Tree Improvement Research Program. *E. viminalis* seeds were originally collected from the Canela region in Brazil, and *E. macarthurii* seeds were collected from the Republic of South Africa. At both originating sites, the

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trees experienced winter frosts. Winter and spring frosts are of frequent occurrence in the Pacific Northwest.

Seeds were sown in the botany greenhouse at the University of Washington, Seattle, in June 1979. After germination, the seedlings were transplanted into 15-cm pots filled with a 50:50 mixture of sandy-loam soil. Plants were transferred to the nursery area and exposed to the natural environment. The pots were regularly watered as needed and treated with 5 g of general 5-10-10 (N-P-K) commercial fertilizer in each pot every 4 weeks prior to the planting in the field.

The land was cleared in the late summer and fall of 1979. Seedlings of *A. rubra, E. viminalis, and E. macarthurii* and 50-cm-long unrooted cuttings of *P. trichocarpa* were planted in March of 1980. Planting stocks were randomly assigned to 48 plots of 4 by 3 seedlings planted on 1.8 by 1.2-m spacing (13 m^2 area).

Percentage survival, height, and diameter growth at 15 cm above ground were recorded for all sample plants at the end of the growing seasons of 1981 and 1982. Aboveground biomass production was also measured at the end of the 1981 and 1982 growing seasons by harvesting 24 plants of each species and drying the aboveground plant materials at 75 °C to a constant weight.

Diurnal rainfall and temperature data for the entire study period were obtained from a permanent weather station located about 16 km from the study site.

Results

Survival. At the end of the second growing season (September 1981), the percentage survival was 96% for *A. rubra,* 85% for *P. trichocarpa,* 93% for *E. viminalis,* and 89% for *E. macarthurii* (table 1). Both *Eucalyptus* species, however, failed to tolerate the winter frost periods of 1981, when minimum temperatures fell to -14.4 °C (6.1 °F). There were 37 and 65 nights of frost during the 1980-81 and 1981-82 study periods (from October through September), respectively. The lowest temperatures were -5 °C (23 °F) in 1980-81 and -14.4 °C (6.1 °F) in 1981-82 (fig. 1).

In January 1982 there were 3 days of continuous freezing with minimum temperatures of - 7.2 °C (19 °F) to -14.4 °C (6.1 °C) and maximum temperatures of -1.7 °C (28.9 °F) to -3.9 °C (25.0 °F). These minimum temperatures fall considerably below those of 1980-81 and caused severe damage to both species of *Eucalyptus* but had no apparent effect on the native species. Freezing resulted in top dieback in 96 and 94% of the *E. viminalis* and *E. macarthurii* seedlings, respectively. Both species sprouted again during the third growing season in 1982.

Height growth and biomass production. Height growth and aboveground biomass production were significantly greater in *A. rubra* compared to other species throughout the study (table 1). The ranking of species by height growth was *A. rubra > E. viminalis > P. trichocarpa > E.*.

Table 1—*Survival, growth, and aboveground biomass production of native species and exotic* Eucalyptus *seedlings in the Pacific Northwest*

Species	Percent Survival	Height (cm)	Biomass production (dry metric ton/ha/yr)
Second growing season (1981)			
Alnus rubra	96	345 a	5.2 a
Populus trichocarpa	85	132 b	0.4 b
Eucalyptus viminalis	93	184 c	0.1 b
E. macarthurii	89	97 d	0.2 b
Third growing season (1982)			
A. rubra	94	447 a	5.4 a
P. trichocarpa	82	290 b	0.4 b
E. viminalis	4*	NA	NA
E. macarthurii	6*	NA	NA

Seasonal values in columns not followed by the same letter differ significantly at the 0.05 level.
*Plants were damaged by frost. Most plants affected by frost resprouted later (see text for details). NA = values not available because of frost damage to plants.

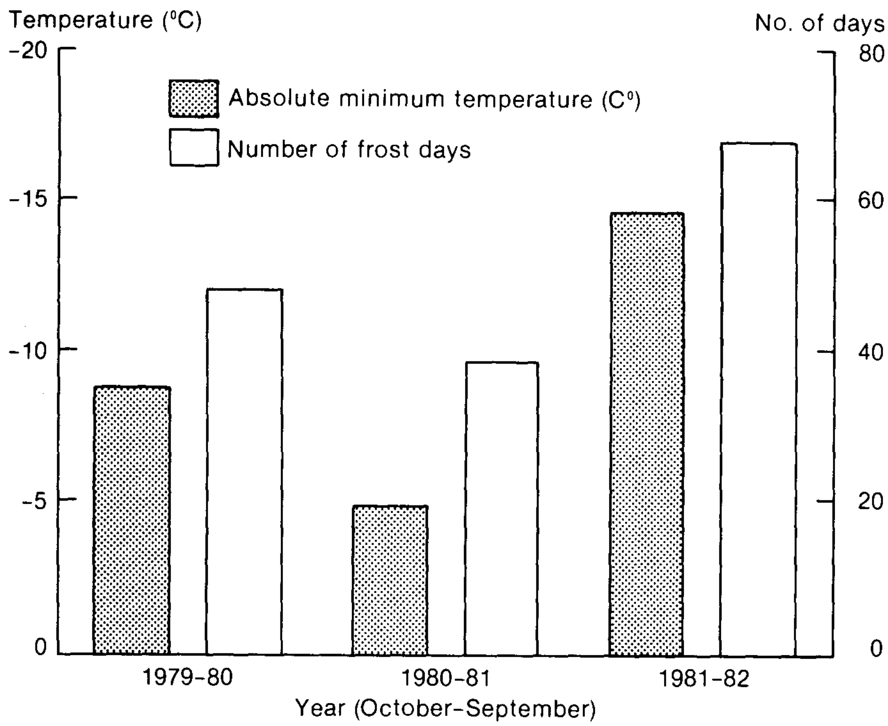

Figure 1—*Absolute minimum temperature and number of frost days during the study at Lee Experimental Forest.*

macarthurii. The ranking for biomass production was *A. rubra* > *P. trichocarpa* > *E. macarthurii* > *E. viminalis.*

Discussion

Two major environmental factors of concern in evaluating exotic *Eucalyptus* plantation in the Pacific Northwest were the frequent seasonal summer droughts and winter frosts.

Annual precipitation and the distribution throughout the year, however, did not apparently limit survival and growth of *Eucalyptus* species in the Pacific Northwest region, at least for the direction of this study. Generally, the average annual precipitation of 1,100 mm for the region is more than the average precipitation in the natural range of the two *Eucalyptus* species as reported by Hall et al. (5).

Low temperature, however, did prove to be a major factor limiting growth of both *Eucalyptus* species, which suffered severely from frost-caused dieback. This finding further emphasizes the importance of careful seed source selection for exotic species plantations. There is a broad range of variation within species that results from natural selection.

Acclimation to cold temperatures for different provenances of the same species is primarily related to seed source. The importance of provenance stock selection for *E. viminalis* in colder areas of Brazil has been emphasized by work of Stohr and Hoogh (14). Selection of frost-resistant provenances of both *E. macarthurii* and *E. viminalis* also have been further emphasized by data obtained in an intensive trial in southwest France (11).

A great variation in level of frost resistance and growth of different seed sources of *E. viminalis* was found for provenances introduced in the State of Georgia. Plants of different seed sources showed frost resistance ranging from no damage, damaged on terminal, and complete dieback (9). The damage was attributed to the large rapid temperature fluctuations during freezing periods rather than absolute low temperatures (9, 10).

Freezing damage of varying degrees to *E. viminalis* seedlings has been reported for *E. viminalis* in Georgia. No permanent damage, however, was found for *E. macarthurii* (9).

A comprehensive test of seedlings obtained from a wide range selection of seed sources from colder regions is needed before conclusions can be drawn about the suitability of these *Eucalyptus* species in the Pacific Northwest region.

The aboveground biomass obtained during the prefrost period for *Eucalyptus* species in this study was lower than native species. Heilman et al. (7) reported that aboveground biomass production of *P. trichocarpa* was between 2.6 to *7.5* metric tons dry weight per hectare per year for the first 2-year rotation period. In addition, plants grown on a spacing of 0.30 by 0.30 m had a higher yield compared to those at 0.61 by 0.61 m and 1.22 by 1.22 m spacings. Plots of 2-year-old coppice of *P. trichocarpa* and *A. rubra* with 0.6 by 1.2 m spacing yielded between 4.7 and 11.1 tons dry weight per hectare per year (2). However, Pezeshki and Oliver (13) reported that a 1.8 by 1.2 m spacing plantation of *A. rubra* produced an average of 0.74 metric dry tons per hectare and *P. trichocarpa* produced 0.04 metric dry tons per hectare by the end of the first growing season. The low yield found for both species was attributed to the site quality and spacing.

Area-based comparisons, however, are difficult because spacing in the present study was much wider than in other reported studies. Close spacing in the other studies would have given more individuals per hectare and, consequently greater apparent per-hectare biomass, at least during the early stages when the intertree competition is minimal. In addition, the less productive soils of this study contributed to low yields found for native and exotic species.

In conclusion, given the great variability of the *Eucalyptus* species to frost damages in other regions, further tests on more frost-resistant *Eucalyptus* species and/or provenances of the two species used for this study are needed for evaluating the potential for fast growing exotic species in the Pacific Northwest.

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