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SEEDLING GROWTH OF EIGHT NORTHWESTERN TREE SPECIES OVER THREE WATER TABLES

by

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ABSTRACT

Seedlings of eight northwestern tree species were grown over controlled water table depths of 7.5, 35.5, and 66.0 centimeters. Lodgepole pine, western redcedar, red alder, and Sitka spruce were all tolerant of shallow water tables. However, lodgepole pine and western redcedar grew best over the deepest water table, as did western white pine. Douglas-fir was intolerant of shallow water tables. Western hemlock and Pacific silver fir were not significantly affected by depth of the water table.

INTRODUCTION

Selecting the best tree species for a forest site is essential for full production, but basic data on species and site are scarce. Furthermore, many of the existing data are difficult to compare--individual species often are studied under different experimental conditions, and site quality is influenced by many environmental factors that affect different species differently. For example, some species cannot grow in areas where water tables are near the surface, while others seem to grow well in such areas.

Stephens[1] found lodgepole pines growing in marshes where water tables were at the surface during much of the year. Godman[2] concluded that water table levels affect the growth of yellow birch, and Phillips and Markley[3] related water table depths to the site index of sweetgum. However, these authors did not compare species. McClurkin[4] compared the growth and phenology on shallow water table sites of baldcypress, white ash, and sweetgum after thinning. But, because the water table depth was different for each of these three species, comparison of species growth over shallow water tables is difficult.

Mueller-Dombois[5] [6] compared the growth of jack pine, red pine, black spruce, and white spruce over controlled water tables in a greenhouse. He used artificial slopes to produce water table depth gradients, and the four species were planted along these gradients. Lateral root growth upslope from shallow portions of the gradients produced minor inconsistencies in Mueller-Dombois' data, but he determined an optimum water table depth for seedlings of each species. This optimum depth differed with soil texture.

Controlled water table depths and uniform soil texture were used in the present study to compare the effects of water table depth on seedling growth of eight northwestern species: Douglas-fir, Sitka spruce, western hemlock, western redcedar, red alder, lodgepole pine, western white pine, and Pacific silver fir.

1/ Stephens, F. R. Lodgepole pine--soil relations in the northwest Oregon Cascade Mountains. J. Forest. 64: 184-186, illus. 1966.

2/ Godman, R. M. Are water table levels an important factor in the establishment and growth of yellow birch? Papers Mich. Acad. Sci., Arts and Letters 44: 183-190. 1959.

3/ Phillips, John J., and Markley, Marco L. Site index of New Jersey sweetgum stands related to soil and water-table characteristics. Northeastern Forest Exp. Sta. USDA Forest Serv. Res. Pap. NE-6, 25 pp., illus. 1963.

4/ McClurkin, D. C. Diameter growth and phenology of trees on sites with high water tables. Southern Forest Exp. Sta. USDA Forest Serv. Res. Note SO-22, 4 pp., illus. 1965.

5/ Mueller-Dombois, Dieter. Effect of depth to water table on height growth of tree seedlings in a greenhouse. Forest Sci. 10: 306-316, illus. 1964.

6/ Mueller-Dombois, D. Technique for studying soil-water-growth relations on an artificial slope. *In* Forest-soil relationships in North America. Corvallis: Oregon State University Press, pp. 153-161, illus. 1965.

MATERIALS AND METHODS

Plastic tiles were cemented to plastic sewer pipe to form cylindrical pots 76 centimeters in height and 10 centimeters in diameter. Small holes drilled in the sides of the pots made them water-permeable. The pots were placed in plastic refuse barrels (68.5 centimeters in height) through holes cut in the barrel covers. Eight pots were placed in each barrel (fig. 1). Pots then were loosely filled with blended sandy loam, and the refuse barrels were filled with water supplied from a gravity-flow water system connected to the barrels with plastic pipe and Tygon tubing.[7] A slow, continuous waterflow through the filled barrels was maintained by screw clamps on the tubing.

Figure 1.—Refuse barrel with soil-filled pots at beginning of study. Note Tygon tubing and screw clamp used to regulate waterflow.

Fifteen refuse barrels containing 120 pots were spaced 2 meters apart. Single drainage holes were made in the sides of 10 barrels--five at 35.5 centimeters and five at 66.0 centimeters below the soil surface in the pots. No drainage holes were made in the remaining

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[7] Mention of a proprietary name does not imply endorsement or approval of the product by the U. S. Department of Agriculture to the exclusion of others which may also be suitable.

five barrels. Three artificial water table depths were thus established at 7.5, 35.5, and 66.0 centimeters below the soil surface. Each of the three depths was assigned at random to five refuse barrels. Species were also placed at random in each barrel, with one species in each of the eight pots. The refuse barrels were located in a level, open field at Cascade Head Experimental Forest near Otis, Oregon, at an elevation of 160 feet.

Seeds of all eight species were obtained from low-elevation, coastal seed sources. They were germinated in petri dishes and 15 were planted in each of the randomly assigned pots in each refuse barrel in May 1966. All drainage holes were plugged to provide abundant soil moisture during the summer, but most of the seedlings died in July and August. Lack of shade and surface drying of the dark, heat-absorbing soil surface may have been responsible for this loss. All seedlings were removed in the autumn, and the experiment was repeated in 1967.

Seeds were again planted at random in each refuse barrel in 1967, but this time 20 seeds of the same species were sown in each pot and covered with 1 centimeter of a fine-grade granite grit. The western white pine seeds were sown in January and allowed to stratify; the other seeds were sown in March. A wooden screen approximately 12 centimeters high was constructed along the southern edge of each pot to provide shade.

Germination began in April 1967. All drainage holes were again plugged to provide abundant soil moisture during the summer, and all first-season seedling growth occurred over the same shallow water table. First-year survival of all species was excellent.

In September the seedlings were thinned, leaving two seedlings in each pot. Drainage holes were unplugged during the first fall rains in October to establish water table depths of 7.5, 35.5, and 66.0 centimeters; these depths were maintained for the duration of the study. All pots were fertilized three times with equal amounts of nutrient solution[8/] during the summer of 1968. A slow waterflow through the refuse barrels maintained constant water table depths, but none of the pots were watered from above. However, precipitation provided some surface water during the summer of 1968.

Surviving seedlings were counted in September 1968. Pots were then broken, and roots were carefully washed free of soil. The shoot and roots of the largest surviving seedling in each pot were oven-dried

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[8/] 1.6 g. $Ca(NO_3)_2$, 1.0 g. KNO_3, 0.5 g. $MgSO_4$, and 0.3 g. KH_2PO_4 per liter of water.

at 65° C. for 48 hours and weighed. The data were subjected to split-plot analyses of variance using the refuse barrels as main plots.

RESULTS

All Sitka spruce, western redcedar, lodgepole pine, and Pacific silver fir seedlings survived. All Douglas-fir seedlings also survived over water table depths of 35.5 and 66.0 centimeters, but 40 percent died over the 7.5-centimeter water table. Red alder survival was poorest over the deepest (66.0 centimeters) water table. There was no correlation between western hemlock and western white pine mortality and water table depth.

Inherent growth rate differences resulted in significant size and weight differences between species. Red alder was the fastest growing; western hemlock, Pacific silver fir, and western white pine were the slowest. These inherent differences, which were evident over all three water tables, are illustrated in figure 2.

Figure 2.—Seedlings at conclusion of study — 66.0-centimeter water table. Clockwise from left corner of numbered card, the species are: Sitka spruce, lodgepole pine, western white pine, red alder, western hemlock, Douglas-fir, and Pacific silver fir. Western redcedar occupies the center pot.

Average seedling weights are listed in table 1. The analyses of variance showed highly significant species differences and highly significant species-water table interactions. Alder seedlings were much heavier than seedlings of any other species over all three water tables; Pacific silver fir and western hemlock seedlings were noticeably lighter than seedlings of any other species. Weight differences and species-water table interactions are less evident for the other species. These differences and interactions are illustrated in figures 3-5. Red alder was omitted in figure 5 to permit large-scale illustration of the other species relationships on a single coordinate system.

Table 1.--*Average shoot weight, root weight, and total weight of largest surviving seedling in each pot by water table depth and species*

Species	Water table depth		
	7.5 centimeters	35.5 centimeters	66.0 centimeters
	Grams		
Shoot weight:			
Red alder	4.25	41.11	13.09
Western redcedar	.76	2.90	3.10
Lodgepole pine	1.32	2.45	3.25
Douglas-fir	.09	1.99	1.56
Sitka spruce	.37	1.77	1.38
Western white pine	.09	.49	.90
Pacific silver fir	.13	.27	.15
Western hemlock	.11	.08	.08
Root weight:			
Red alder	2.01	18.59	8.25
Western redcedar	.31	1.30	1.54
Lodgepole pine	.40	.92	1.13
Douglas-fir	.05	.75	.85
Sitka spruce	.22	.81	.62
Western white pine	.07	.39	.74
Pacific silver fir	.13	.22	.13
Western hemlock	.05	.06	.04
Total weight:			
Red alder	6.26	59.70	21.34
Western redcedar	1.07	4.20	4.64
Lodgepole pine	1.72	3.37	4.38
Douglas-fir	.14	2.74	2.41
Sitka spruce	.59	2.58	2.00
Western white pine	.16	.88	1.64
Pacific silver fir	.26	.49	.28
Western hemlock	.16	.14	.12

Figure 3.—Lodgepole pine seedlings at conclusion of study, grown over 7.5-centimeter (left), 35.5-centimeter (center), and 66.0-centimeter (right) water tables.

Figure 4.—Douglas-fir seedlings at conclusion of study, grown over 7.5-centimeter (left), 35.5-centimeter (center), and 66.0-centimeter (right) water tables.

Western hemlock and Pacific silver fir seedlings were not significantly affected by the different water table treatments. Slow growth rather than shallow water table tolerance probably was responsible; they grew very slowly on all three water tables. Therefore, these two species are not compared with the other species in figure 5. The shallow (7.5 centimeters) water table adversely affected all other species.

Red alder, Sitka spruce, and Douglas-fir seedling weights were heaviest over the 35.5-centimeter water table, but Douglas-fir root weights were heaviest over the 66.0-centimeter water table. Lodgepole pine, western redcedar, and western white pine seedlings were heaviest over the 66.0-centimeter depth.

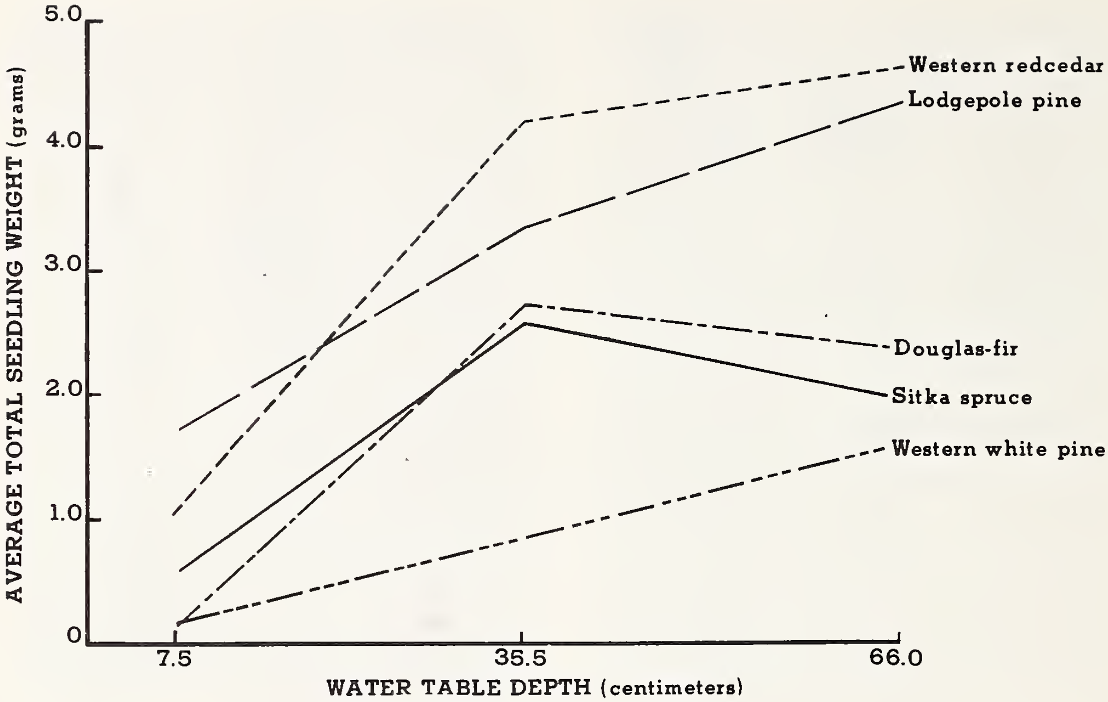

Figure 5.—Relationship of seedling weight to water table depth, by species.

DISCUSSION

Data indicate that, although lodgepole pine and western redcedar are suitable species for shallow water table areas, they seem to grow best over deeper water tables. Red alder and Sitka spruce, also suitable for shallow water table areas, seem less suited to deep water tables. Douglas-fir is not tolerant of shallow water table depths and should not be planted where water tables are near the surface.

The artificial nature of this experiment should be emphasized. The absolute water table depth information presented here cannot be applied as such in the field. However, relative species relationships should be so applicable; red alder, Sitka spruce, lodgepole pine, and western redcedar seedlings should grow better than Douglas-fir seedlings over shallow water tables on coastal sites. Future field measurements and observations should make it possible to quantify these species relationships.