AN INTEGRATED STUDY OF NURSERY STOCK CONDITIONING: PRELIMINARY OBSERVATIONS ON STOCK PERFORMANCE

William I. Stein
Principal Plant Ecologist
Pacific Northwest Experiment Station
USDA, Forest Service
Corvallis, Oregon

ABSTRACT

Relationships between several nursery cultural practices and subsequent field survival and growth of Douglas-fir seedlings on different sites are being investigated. Results of an exploratory study indicate that both wrenched and unwrenched seedlings increased substantially in stem diameter and root dry weight after early August, that by early winter they were nearly the same size, and that an early August wrenching did not improve their firstseason field survival or height growth. Design of the larger followup investigation is described and some observations on frost damage at different seedbed densities, chilling requirements, and relationships between nursery cultural practices and midseason first-year survival are reported.

During the past decade, the culture of Douglas-fir nursery stock to improve its storability and field performance has received increasing attention. Effects of individual nursery practices such as bed density (Edgren 1975a, 1977a, 1977b), undercutting (Edgren 1971), wrenching (Edgren 1975b; Tanaka, Long, and Winjum 1975; Tanaka, Walstad, and Borrecco 1976), irrigation (Cleary 1971), and lifting time (Zaerr and Lavender 1972) have been investigated. Much has been learned but gaps remain, particularly on the interacting effects of different practices. With the assistance of several cooperators, the Pacific Northwest Forest and Range Experiment Station's Reforestation Systems Research Project initiated coordinated studies in 1976 to determine the combined effects of several nursery practices. This paper contains some initial results and observations from studies still in progress. The preliminary data are indicative of trends or relationships but have not been subjected to statistical analysis.

EXPLORATORY STUDY

To test procedures and settle on seedling evaluation techniques, we conducted some preliminary trials using one lot of 2-0 Douglas-fir stock growing at moderate density (about 30 per square foot) in the D. L. Phipps State Forest Nursery at Elkton, Oregon. The nursery's usual second-season production practices had been applied to the lot--undercutting in late

April, vertical root pruning in early June, and fertilizing with 250 pounds of 27-12-0 in April and May. Seed origin was from the 2,000-foot level in seed zone 492 on Bureau of Land Management, U.S. Department of the Interior, lands in the South Umpqua River drainage southeast of Roseburg.

On August 2, 1976, 50 bed feet of this stock were wrenched at 7-inch depth with an oscillating wrencher blade. Another 50-foot segment in the same bed was left unwrenched as a control. Plant moisture stress in the wrenched stock averaged 12.25 bars before dawn the next day. Since irrigation practices at Phipps Nursery called for reducing stresses over
12 bars, the entire bed of seedlings was irrigated for 2 hours on August 3.

Samples of the wrenched and unwrenched seedlings were lifted on August 26, September 14, October 5, and October 29, 1976, and on January 18, 1977.
On the first four dates, seedlings were dug with a tile spade; on the final date they were loosened by machine at 10-inch depth. At each lifting, trees were taken from four well-spaced points in wrenched and unwrenched bed segments separately and systematically allotted to several 10-tree subsamples, each of which received about an equal number of seedlings from each sampling point. Roots of bundled trees were pruned to a 10-inch length. Subsamples were then randomly designated for different purposes--measurement of seedling size, greenhouse growth test, growth test in an outdoor bed, and anatomical examination. Forty wrenched and forty unwrenched seedlings from each lifting were measured for top length and stem diameter; top and root dry weights were determined for half of these. Some seedlings from the January 18 lifting were outplanted the same day on droughty sites in the Shively Creek drainage south of Days Creek, Oregon. Fifty wrenched and fifty unwrenched seedlings were randomly allotted to planting spots arranged in a 10- X 10-foot grid. Identical plantings were made in two broadcast-burned clearcuts, one on a moderate south slope, the other a half mile away on a steep east slope.

Size changes

Size of wrenched and unwrenched seedlings increased appreciably in the nursery during fall and early winter as indicated by successive samplings. Upward trends that appear to exceed sampling variation were evident for average stem diameter and ovendry weight but not for top length. From late August to mid-January, seedling diameters appear to have increased about 50 percent (fig. 1). Diameter of wrenched seedlings tended to be smaller at first, but by January there was little difference between wrenched and unwrenched seedlings.

Average dry weight of unwrenched seedling roots more than doubled from August to January; for wrenched seedlings it was five times greater (fig. 2). Roots of wrenched seedlings weighed about half as much as those of unwrenched seedlings in August, and logically so, since they had been pruned 24 days before. But by January, root weights of wrenched seedlings were at least as heavy as for unwrenched seedlings.

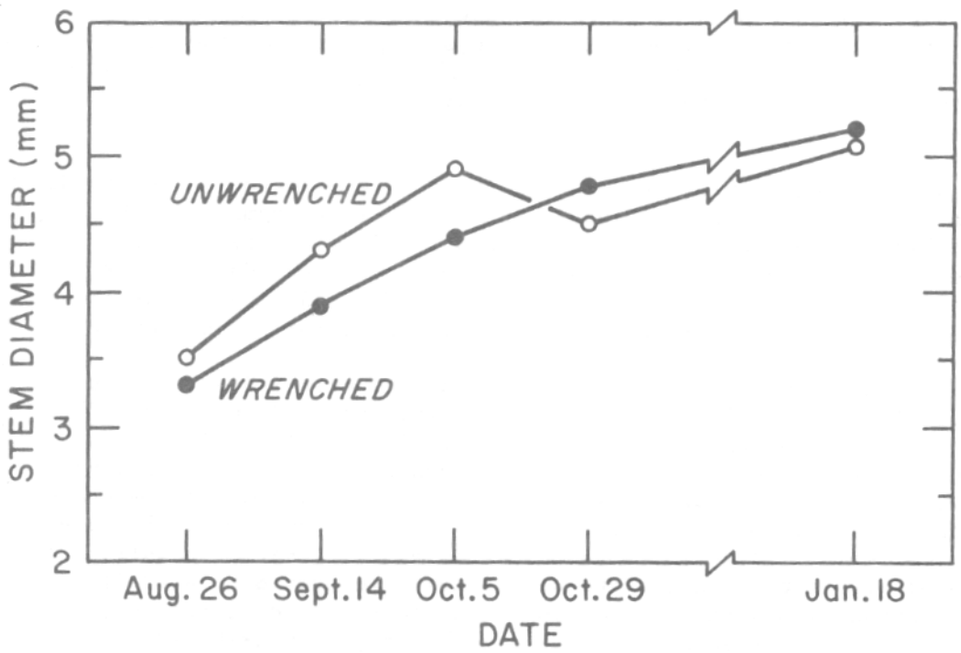

Figure 1.--Post-treatment change in average stem diameter as determined from successive destructive samples.

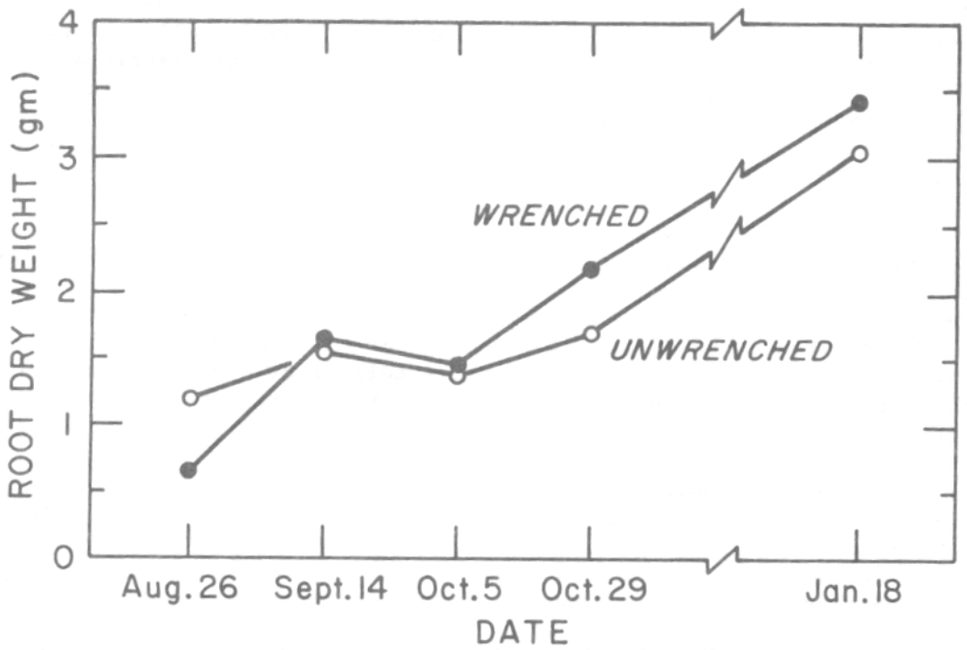

Figure 2.--Post-treatment change in average dry weight of seedling roots as determined from successive destructive samples.

Top-root ratios reflect the sizable changes in root weight during fall and early winter (fig. 3). Top-root ratios were about 3:1 in late August hut decreased to less than 2:1 by mid-January.

In the mid-1960's, Krueger and Trappe (1967) observed stem diameter increases as well as root growth after September on two lots of stock at Wind River Nursery, but the magnitude of that increase was not clearly indicated. Obviously, the increase may be very substantial.

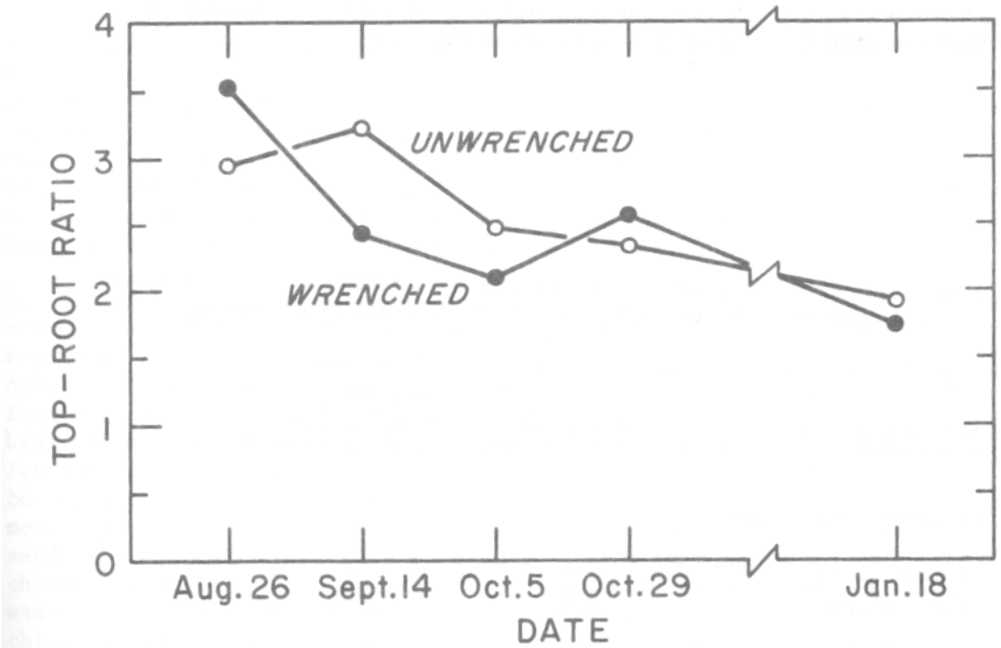

Figure 3.--Post-treatment change in seedling top-root ratio as determined from successive destructive samples.

Field performance

Seedlings planted near Days Creek in January were checked for survival in late May 1977 and again in June 1978. Initial height and 1st-year increment were also measured.

First-year survival of both wrenched and unwrenched seedling was very good:

Aspect	Wrenched	Unwrenched
	Percent	
South	94	94
East	90	86
Average	92	90

In fact, survival was surprisingly good considering that the areas were chosen for their droughty nature and 1977 was exceptionally dry until late in the year. Differences in survival of wrenched and unwrenched stock appear unimportant.

First-year height growth was consistently greater for unwrenched stock--whether based on all live seedlings or only on those (about 50 percent) that had not been browsed (Table 1).

Unwrenched seedlings of the same lot which were tested in the greenhouse or in outdoor beds also tended to grow slightly more in height the first season than their wrenched counterparts.

Clearly, performance after outplanting was not enhanced by wrenching Douglas-fir seedlings of this lot once in early August.

Table 1. Average 1st-year height growth of wrenched and unwrenched Douglas-fir seedlings planted on two droughty sites

Seedling group	Stock treatment	
	Wrenched	Unwrenched
	cm	
All live seedlings:		
South slope	5.6	6.6
East slope	3.8	4.7
Average	4.7	5.6
Unbrowsed seedlings:		
South slope	6.9	7.3
East slope	4.7	5.5
Average	5.8	6.4

MAIN INVESTIGATION

In September 1976, 1-0 seedlings in parts of several seedbeds at the Wind River and D. L. Phipps nurseries were thinned to densities of 10, 15, and 30 per square foot. The seed source selected at Phipps came from 1,500 feet in the Dillard management area (Roseburg District, Bureau of Land Management), seed zone 270; and the one at Wind River from 3,000 feet in the North Umpqua management area, seed zone 491. During their second season, seedlings in 18 of 54 thinned plots were undercut in the spring at a 6-inch depth, the usual nursery practice. The other two-thirds were undercut when seedlings averaged 8 inches tall. Thereafter, half of these (18 plots) were wrenched at a 9-inch depth every 3 weeks till September. The rest of the plots were also wrenched at 3-week intervals and root pruned vertically every 6 weeks. After June 15, half of the total plots (27) received moderate irrigation, the other half continued to receive abundant irrigation. The design provided 18 treatment combinations, each replicated three times.

At least 60 seedlings were dug with a tile spade from successive swaths across each plot in September, October, and November 1977, and the remainder were lifted in January 1978 at Wind River or February at Phipps. After roots were pruned at 10 inches, separate 10-tree samples of seedlings from each plot and each lifting were measured for size, planted in outdoor beds to determine survival and height growth in 1978, tested immediately for shoot and root growth in the greenhouse and also after 90 days of cooler storage, and examined anatomically for stage of meristem development. Winter-lifted stock of each seed source was outplanted in its seed zone. Three replicated blocks were located on each of four clearcuts chosen for their contrasting aspects or soils. Each of the 18 treatments was represented by one row of 20 trees per block. Results on frost damage, chilling requirements, and midseason field survival are now available.

Frost damage

In the spring of 1977, frost damaged the 1-year-old seedlings at both nurseries. The damage occurred more than 6 months after seedlings had been thinned, but before they were subjected to undercutting and wrenching or irrigation treatments. We counted the number of damaged seedlings in the fourth row of each plot. The amount of visible damage was not related to bed density (Table 2).

Table 2. Percent of seedlings damaged by spring frost in seedbeds thinned to three densities at two nurseries

Seedlings per square foot	Seedlings damaged	
	D. L. Phipps State Forest Nursery	Wind River Nursery
	Percent	
10	19.4	10.0
15	25.9	9.5
30	23.0	11.7

Chilling requirements

Terminal buds on seedlings lifted between late August and November from both the exploratory and the main investigation generally would not flush when placed immediately under growing conditions in the greenhouse. Flushing of some lateral buds occurred, but it was erratic and growth tended to be less than normal. It is known that dormant Douglas-firs require chilling before resuming height growth, but the amount needed is ill defined. Most seedlings lifted at Wind River as late as November 17, after they had already been subjected to low nighttime temperatures for 7 weeks, did not flush in the greenhouse. In contrast, terminals on seedlings lifted the same date and stored at 1.5°C for 90 days before placement in the greenhouse flushed rapidly and made good growth (fig. 4).

Figure 4.--Douglas-fir seedlings must have sufficient chilling to resume height growth. Left, terminal buds still not flushed in May on seedlings placed in growing conditions immediately after lifting on November 17; right, same stock held in cool storage for 90 days and then placed in growing conditions.

Field survival

Seedlings field planted in late winter were first examined in June 1978.

Data from that examination have been summed to see if initial survival was related to any of the nursery production practices under test.

Three months after planting, seedling survival did not appear strongly related to nursery cultural practices. Survival of North Umpqua source stock was very high, but there was substantial mortality and dieback of Dillard source stock (Table 3). Seedbed density had no apparent effect, but survival tended to be slightly higher for seedlings that were wrenched. The largest survival difference was between irrigation regimes--abundantly watered seedlings of the Dillard source had the most mortality.

Table 3. Average field survival by midseason of Douglas-fir seedlings from two sources subjected to the same cultural practices at separate nurseries.

Cultural practice and level	Stock source	
	North Umpqua	Dillard
	-- Percent survival ---	
Bed density, seedlings per square foot:		
10	95.8	75.9
15	95.7	72.7
30	95.9	73.1
Root treatment:		
Undercut only	93.6	69.7
Undercut and wrenched	96.7	74.8
Undercut, wrenched, and vertically pruned	97.2	77.3
Irrigation:		
Moderate	96.2	82.8
Abundant	95.4	65.0

These preliminary data need to be viewed cautiously, however. At Phipps nursery, some heavily watered stock was also stressed the most, as evidenced by the amount of mortality that appeared after wrenching. Furthermore, some seedlings that were heavily stressed in the summer were also subjected to extremely wet conditions prior to lifting. Present survival differences could prove illusory--seedlings from other treatments might only be fading slower, and the final results might be quite different.

Future work

General nursery experience, related studies, as well as our preliminary field data, all indicate that water regime is a key element in seedling conditioning. Seedlings that receive less water set buds sooner. How usefully wrenching adds to the water stress effect must still be learned, since in our study seedlings that remained undisturbed since undercutting early in the season were the deepest green and had the most prominent buds in August.

Efforts to learn the combined effects of nursery practices on seedling field performance are continuing. In fall 1977, another set of study plots was installed, this time in 1-0 beds of the same seed source growing at both the D. L. Phipps and Humboldt nurseries. During 1978, the same density, irrigation, and wrenching treatments have been applied. Early in 1979, stock from those plots will also be outplanted on clearcuts in the Roseburg District of the Bureau of Land Management.

LITERATURE CITED

Cleary, Brian Dennis.
1971. The effect of plant moisture stress on the physiology and establishment of planted Douglas-fir and ponderosa pine seedlings. Ph.D. thesis, Oreg. State Univ., Corvallis. 85 p., illus.

Edgren, James W.
1971. Survival and growth of undercut Douglas-fir nursery stock after outplanting. West. For. Nursery Counc. and Intermountain For. Nurserymen's Assoc. Meeting Proc., Edmonton, Alberta, Aug. 3-5, 1971. 3 p. (Abstr.).

1975a. Douglas-fir 2+0 nursery stock size and first-year field height growth in relation to seed bed density. USDA For. Serv., Servicewide Conf. on Planting Stock Production Proc., Coeur d'Alene, Idaho, Sept. 16-18, 1975. p. 72-79, illus.

1975b. Wrenching--recent developments in an old technique. West. For. Nursery Counc. Meeting Proc., Portland, Oregon, Aug. 5-7, 1974. p. 50-59, illus.

1977a. Seedbed density, diameter limit culling, and 2+0 Douglas-fir seedling production. West. For. Nursery Counc. and Intermountain For. Nurserymen's Assoc. Meeting Proc., Richmond, British Columbia, Aug. 10-12, 1976. 9 p.

1977b. Seedbed density-seedling performance relationships for Douglas-fir. West. For. and Conserv. Assoc., Proc. 1976 West. For. Conference, Portland, Oregon, Nov. 30 - Dec. 2, p. 75.

Krueger, Kenneth W., and James M. Trappe.
1967. Food reserves and seasonal growth of Douglas-fir seedlings. For. Sci. 13:192-202, illus.

Tanaka, Yasuomi, A. J. Long, and J. K. Winjum.
1975. Effects of undercutting and wrenching on 2+0 Douglas-fir seedlings. West. For. Nursery Counc. Meeting Proc., Portland, Oregon, Aug. 5-7, 1974. p. 60-71.

, J. D. Walstad, and J. E. Borrecco.
1976. The effect of wrenching on morphology and field performance of Douglas-fir and loblolly pine seedlings. Can. J. For. Res. 6:453-458, illus.

Zaerr, J. B., and Denis P. Lavender.
1972. Lifting dates and storage of Douglas fir nursery stock. West. For. Nursery Counc. and Intermountain For. Nurserymen's Assoc. Joint Meeting Proc., Olympia, Washington, Aug. 8-10, 1972. p. 119-124.