Fall-Lifted Douglas-Fir Outperforming Spring-Lifted Stock 13 Years After Planting

John P. Sloan

Forester, Intermountain Research Station, USDA Forest Service, Boise, ID

*A 1972 study showed that Douglas-fir (*Pseudotsuga menziesii *var*. glauca*) seedlings lifted in mid-November outgrew those lifted in early March. When the plots were remeasured in 1985, after 13 growing seasons on a south-facing granitic slope in central Idaho, the fall-lifted trees continue to grow faster than the spring-lifted seedlings.* Tree Planters' Notes 40(3):20-24; 1989.

In 1972, a study was undertaken at Lucky Peak Nursery by Morby and Ryker (10) to determine the feasibility of late-fall lifting, cold storage, and spring planting of several conifers in southwestern Idaho. They found that ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), lodgepole pine (*Pinus contorta* Dougl. ex Loud.), Engelmann spruce (*Picea engelmannii* Parry ex Englem.), and western larch (*Larix occidentalis* Nutt.) seedlings lifted in late fall and stored through the winter survived and grew as well as spring-lifted stock. Surprisingly, however, the fall-lifted Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) seedlings not only survived as well but also grew almost twice as much as did the spring-lifted seedlings (11).

Although the timeframe of the original study was only three growing seasons, we visited and remeasured the Douglas-fir plots in September 1985 to see if the growth differential continued for the 13 years since planting.

Original Study and Followup

Seedlings grown at Lucky Peak Nursery near Boise, ID, were lifted in mid-November after oscilloscope traces indicated dormancy. Half of the trees were packed in polyethylene-lined paper bags and the other half in open-ended wooden crates. Half of the seedlings in each type of package were held in cold storage at 28 °F (-2.2 °C) from November 13 until April 2, when they were placed in storage at 33 °F (0.6 °C) and held until they were shipped to the planting site on May 3. The other half were stored at 33 °F the entire time between lifting and shipping.

For comparison, seedlings of the same age, from the same seedlot, grown in an adjacent seedbed were lifted and packed in early March. Again, seedlings were stored in bags and crates but at only one temperature, 33 °F (0.6 °C), from March 7 until May 3. Nursery soil, site characteristics, cultural treatments, and seedling size were essentially the same for fall- and spring-lifted stock.

The planting site is located in the Wetfoot Creek drainage on the Emmett District of the Boise National Forest. The Douglas-fir seedlings were planted in granitic soils on a south aspect at an elevation of about 5,000 feet (1,524 m).

In early May, trees were planted in three blocks; each block contained six plots, one for each treatment. The 24- by 14-foot (7.3- by 4.3-m) plots were completely cleared to mineral soil using hand tools. Fifty trees were planted on each plot, and the trees were spaced 2 feet (0.6 m) apart both within and between rows. Seedlings were planted in 1973; their growth and survival were measured after the first (1974) and third (1976) growing seasons. Thirteen years after planting (1986) we took follow-up measurements, which had not been planned for in the original study.

Seedling Survival and Growth

First-year records show that significantly fewer of the trees packaged in crates and stored over winter at 28 °F (-2.2 °C) survived than trees subjected to the other treatments (a = 0.05) (10). Because the humidity in the freezer storage varied between 52 and 69% the lower survival was attributed to the drying of exposed tops. I n the 33 °F (0.6 °C) cooler the average humidities were in a more favorable range: 85 to 92%. Third-year survival showed the same difference between treatments (11). But after 13 growing seasons, the survival of fall-lifted seedlings

stored in crates at 28 °F differed only from the spring-lifted seedlings (table 1).

Mean seedling height differences between treatments, observed after the first growing season, continued through the third year. Crated trees stored at 28 °F did not grow as much as the other fall-lifted seedlings and were similar in height to springlifted trees (11). Mean seedling height differences between spring- and fall-lifted treatments increased from the third to the thirteenth year, but at the 95% confidence level the only significant difference is between the fall-crated seedlings stored at 33 °F and the spring-lifted seedlings stored in bags (table 1).

The 1985 height figures may be somewhat misleading, because the results were seriously confounded by the close tree spacing and die-back of tops. Seedlings were planted with 2-foot spacing to reduce space requirements, costs, and and site variability within the plots. Because the original objectives did not call for long-term monitoring of tree growth, interpretation of follow-up measurements is difficult.

Most of the die-back occurred in the plots of fall-lifted stock (fig. 1). The die-back is due, at least in part, to competition-related stress in the trees and is compounded by the harsh south-facing site where moisture is probably the limiting factor for growth. For each treatment, as the mean height has increased, the number of cases of top dieback has also increased. In other words, the fall-lifted trees are larger and have reached a point of more intense competition for space than the spring-lifted trees. Therefore, the mean height differences between treatments have actually been reduced.

More meaningful than the mean height and survival after 13 years is the percentage of trees more than 10 ft (3 m) tall (fig. 2). Twenty percent of all fall-lifted trees alive after 13 years were more than 10 feet in height, whereas only 0.5% of the spring-lifted trees were more than 10 feet. Figure 3 illustrates the height differences between spring-lifted crated seedlings on the left and fall-lifted crated seedlings on the right by the measuring pole. The seedlings in both plots were stored at 33 °F.

Spring-lifting appears to have suppressed height growth of the Douglas-fir seedlings in this study. Morby and Ryker (11) also reported slow initial height growth in operational planting in southern Idaho and foresters continue to make similar observations. Typically, even when survival is good, Douglas-fir go through a bushy stage lasting 3 to 5 years. This phenomenon is probably related to the physio-

Table 1—*Mean field survival and heights of fall- and spring-lifted Douglas-fir from Lucky Peak Nursery 1, 3, and 13 growing seasons after planting*

Month lifted	Storage temperature (°F)	Type Package	Survival (%) 1973	Survival (%) 1975*	Survival (%) 1985	Height (cm) First-yr growth 1973	Height (cm) Total 1975	Height (cm) Total 1985	No. of 10-ft trees/ 100 planted (1985)
Nov.	28	Bag	75 a	67 a	57 ab	6.3 a	39 a	220 ab	8.6
Nov.	28	Crate	57 b	41 b	36 b	4.3 b	25 b	178 ab	4.0
Nov.	33	Bag	90 a	87 a	46 ab	7.5 a	44 a	204 ab	7.4
Nov.	33	Crate	76 a	65 a	61 ab	7.4 a	41 a	243 a	24.6
March	33	Bag	96 a	87 a	81 a	3.7 b	22 b	130 b	0.0
March	33	Crate	93 a	75 a	73 a	3.2 b	22 b	162 ab	0.7

Means in columns followed by the same letter do not differ significantly at the 95% confidence level.
*Some of these survival figures are different than those appearing in Morby and Ryker (11) because of typographical errors in that publication.

logical condition of the planting stock. Slow initial growth is especially undesirable on sites where intense brush competition will overtop young Douglas-fir plantations. In this case, the harsh dry site may have contributed to the difference in growth rates.

Several other studies have also shown that Douglas-fir can be lifted late in the fall and held in storage anywhere from 1 to 6 months without a decrease in survival in the field (1,4,7,12,13,17). Depending on the seed source and location of the nursery, lifting windows for Douglas-fir may open as early as the first part of November (4,5,17) or may not open until mid-December (16). Hermann and others (3) reported that effects of long-term storage are generally negative. Ritchie (15) showed that root regeneration potential increased for the first 6 months of storage, then dropped sharply.

Dick (2) found that cold storage in excess of 5 weeks reduced the height growth of spring-lifted Douglas-fir. Likewise, the storage period of the spring-lifted stock—exceeding 7 weeks—could have reduced height growth of the Douglas-fir seedlings in this study. Lavender (8) showed that, in mild climates, cold storage benefits seedlings lifted in late fall or winter by more efficiently satisfying chilling requirements.

In addition to fulfilling chilling requirements of seedlings, cold storage can have other effects. According to Jenkinson and Nelson (6), Douglas-fir seedings stored in mid-winter doubled their resistance to dehydration and those stored in late winter maintained their high resistance.

Nyland (14) found budburst of spring-lifted Douglas-fir to be as much as 25 days ahead of those coming from cold storage. Depending on the site and weather, seedlings that are so physiologically active might not withstand the stress from transport, temporary storage, planting, spring frosts, or numerous other handling practices and environmental components.

The discrepancy in growth between fall- and spring-lifted stock seems to be due to physiological differences because the

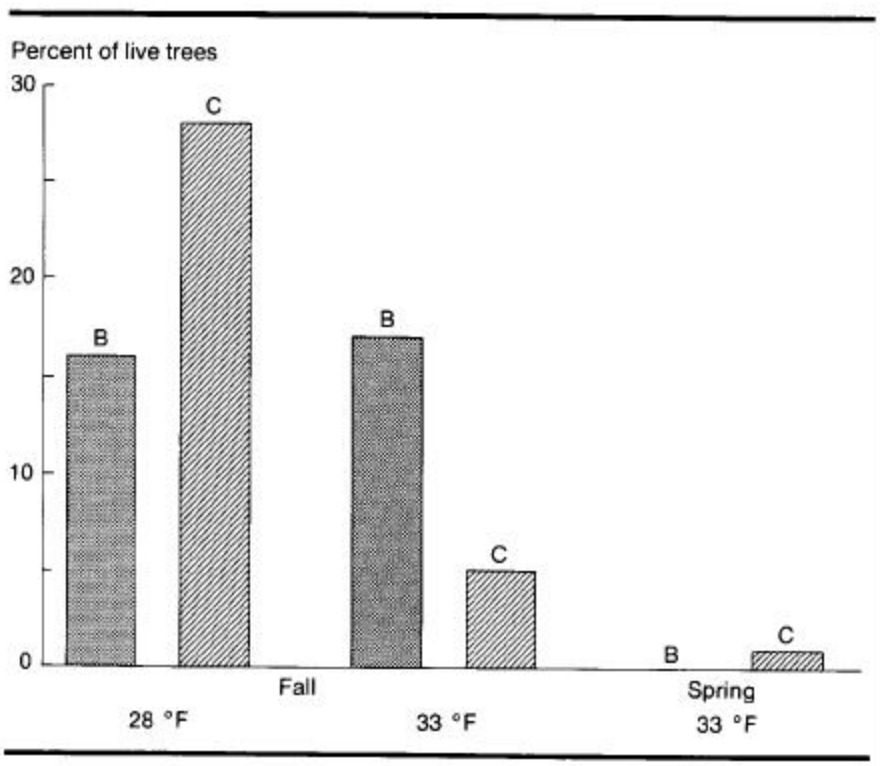

Figure 1—*Mean die-back of Douglas-fir in percentage of live trees after 13 growing seasons. The six treatments are (**1**) fall-lifted, stored in bags (B) at 28 °F, (**2**) fall-lifted, stored in crates (C) at 28 °F, (**3**) fall-lifted, stored in bags at 33 °F, (**4**) fall-lifted, stored in crates at 33 °F, (**5**) spring-lifted, stored in bags at 33 °F, and (**6**) spring-lifted, stored at 33 °F.*

seedlings appeared to be physically and morphologically identical. Douglas-fir lifting windows have been closely studied in the milder coastal zone of the western United States (3-5,8, 9,16), but more study is needed in the continental climate of Lucky Peak Nursery. We do know that the dormancy cycle is very complicated and that it may differ for each seed source and year, depending on weather and cultural practices.

The growth of the spring-lifted stock might have been improved if the winter conditions had allowed an earlier lift date or if the storage time could have been shortened.

Conclusions

The type of package and the storage temperature did not have great or lasting effects on the growth and survival of the Douglas-fir seedling except when the crated trees were exposed to the low humidity of freezing temperatures. Storing trees in crates at 28 °F (-2.2 °C) caused higher initial mortality. In years that followed, survival has not changed much relative to the other treatments.

Two major conclusions can be drawn from the remeasurement of this study. First, fall-lifted Douglas-fir has outgrown spring-lifted stock for 13 years on a harsh site in southwest Idaho. Second, when Douglas-fir seedlings get a good start after planting, the increased height is still noticeable 13 years later. Conversely, after a poor start the spring-lifted trees continue to lag behind in height. We must strive to plant the most vigorous trees possible and plant them properly. If seedling initial height growth is surpressed for any reason, the trees may never catch up.

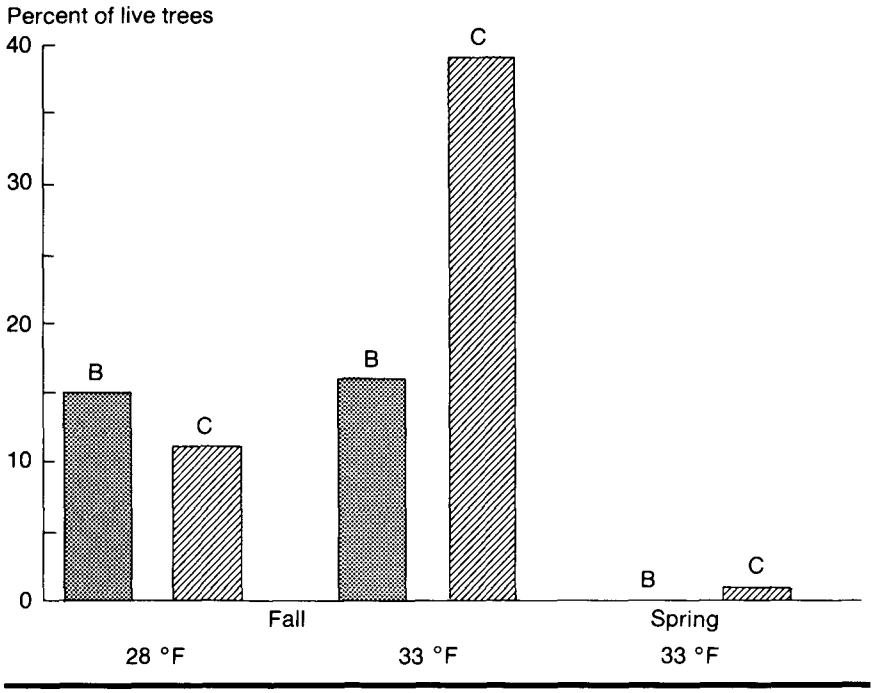

Figure 2—*Mean number of Douglas-fir trees more than 10 feet tall, in percentage of live trees, after 13 growing seasons. The six treatments are (**1**) fall-lifted, stored in bags (B) at 28 °F, (**2**) fall-lifted, stored in crates (C) at 28 °F, (**3**) fall-lifted, stored in bags at 28 °F, (**4**) fall- lifted, stored in crates at 33 °F, (**5**) spring-lifted, stored in bags at 33 °F, and (**6**) spring- lifted, stored in crates at 33 °F.*

References

1. Deffenbacher, F.W.; Wright, E. 1954. Refrigerated storage of conifer seedlings in the Pacific northwest. Journal of Forestry 52(12):936-938.
2. Dick, J. 1963. First-season survival and growth of stored Douglas-fir, noble fir, and ponderosa pine planting stock. For. Res. Note 51. Centralia, WA: Weyerhaeuser Company, Forestry Research Center. 5 p.
3. Hermann, R.K.; Lavender, D.P.; Zaerr, LB. 1972. Lifting and storing western conifer seedlings. Res. Pap. 17. Corvallis, OR: Oregon State University, School of Forestry. 8 p.

Figure 3—*Comparison of fall- and spring-lifted seedling plots after 13 years. The Douglas-fir trees on the right side of the photo were lifted in the fall. Those on the left were lifted in the spring. Both plots shown were crated seedlings stored at 33 °F.*

4. Jenkinson, J.L. 1983. Seed source lifting windows improve plantation establishment of Pacific slope Douglas-fir. In: Duryea, M.L.; Brown, G.N., eds. Seedling physiology and reforestation success. The Hague: Martinus Nijhoff/Dr W. Junk. 27 p.
5. Jenkinson, J.L.; Nelson, J.A. 1978. Seed source lifting windows for Douglas-fir in the Humboldt Nursery. In: Western Forest Nursery Council and Intermountain Nursery man's Association, combined nurseryman's conference and seed processing workshop: Proceedings; 1978 August 7-11; Eureka, CA. San Francisco, CA: USDA Forest Service, Pacific Southwest Region, State and Private Forestry: 77-95.
6. Jenkinson, J.L.; Nelson, J.A. 1985. Cold storage increases resistance to dehydration stress in Pacific Douglas-fir. In: Proceedings: Western Forest Nursery Council Intermountain Nurseryman's Association combined meeting; 1984 August 14-16; Coeur d'Alene, ID. Gen. Tech. Rep. INT-185. Ogden, UT: USDA Forest Service, Intermountain Research Station: 38-44.
7. Lanquist, K.B.; Doll, J.H. 1960. The effect of polythene and regular packing methods on ponderosa pine and Douglas-fir seedlings stored over winter. Tree Planters' Notes 42: 29-30.
8. Lavender, D. 1964. Date of lifting for survival of Douglas-fir seedlings. Res. Note 49. Corvallis, OR: Oregon State University, Forest Research Laboratory. 21 p.
9. Lavender, D.P.; Wright, E. 1960. Don't lift Douglas-fir too early because late lifting increases survival and vigor, studies show. The Timberman 61(8):54-55.
10. Morby, F.E.; Ryker, R.A. 1975. Winter storage and packag ing effects on Lucky Peak seedlings. Res. Note INT-195. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 10 p.
11. Morby, F.E.; Ryker, R.A. 1979. Falllifted conifers successfully spring planted in southwest Idaho. Tree Planters' Notes 30(3):27-29.
12. Novotny, V. 1966. [Results of storing conifer seedlings in polyethylene in the winter of 1965 66] Lesnaya Promyshlennost 45 (11) :487-489.
13. Nyland, R.D. 1974. Fall lifting for over-winter cold storage of conifers. AFRI Res. Rep. 22. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 5 p.
14. Nyland, R.D. 1974. Cold storage delays flushing of conifers. AFRI Res. Note 10. Syracuse, NY: **State** University of **New York, College of Environmental Science and Forestry.** 2 p.
15. Ritchie, G.A. 1982. Carbohydrate reserves and root growth potential in Douglas-fir seedlings before and after cold storage. Canadian Journal of Forest Research 12:905-912.
16. Todd, G. 1964. Douglas-fir seedlings have roots? Journal of Forestry 62:561-563.
17. Winjum, J.K. 1963. Effects of lifting date and storage on 2+0 Douglas-fir and noble fir. Journal of Forestry 61(9):648-654.