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SURVIVAL COMPARISONS OF THREE FALL AND SPRING PLANTINGS OF FOUR CONIFEROUS SPECIES IN NORTHERN IDAHO

Clarence Sinclair and R. J. Boyd

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
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ABSTRACT

First-year survival of four coniferous species, Douglas-fir (Pseudotsuga menziesii var. glauca (Beissn.) Franco), Engelmann spruce (Picea engelmannii Parry), grand fir (Abies grandis (Dougl.) Lindl.), and western larch (Larix occidentalis Nutt.), was determined for 3 consecutive years in northern Idaho. Trees were planted on three dates during the fall and on three dates during the spring. Each planting was on both a north and a south aspect to permit comparisons of differing moisture stress. Survival of spring-planted trees was generally better than that of fall plantings. Fall planting results were more variable and apparently more influenced by species, planting date, and aspect of the planting site. Some probable causes for differences are discussed, together with practical implications to planting programs.

INTRODUCTION

Spring has been the preferred season for planting coniferous forest trees in the northern Rocky Mountain area for many years. Prior to 1940, no distinct preference for any particular season was apparent. Following publication by the USDA Forest Service of survival comparisons between plantations established in the fall and the spring over a 27-year period, preference shifted sharply to spring planting (Schopmeyer 1940).[1] This summary showed a long-term advantage of spring planting that averaged 7 percentage points for western white pine (*Pinus monticola* Dougl.) and 10 for ponderosa pine (*Pinus ponderosa* Laws.). Although not as well represented in the compilations as western white and ponderosa pine, similar results were observed for western larch (*Larix occidentalis* Nutt.), Engelmann spruce (*Picea engelmannii* Parry), and interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco).

Fall planting again became a substantial part of the reforestation effort in the late 1950's and early 1960's. An expanding planting program made it desirable to spread nursery and planting efforts over more time. An even more important consideration is the late spring accessibility of many remote and high elevation planting sites. Where access is blocked by snow, spring planting is either delayed until long after the planting area itself is free of snow or extra expenses must be incurred to get to the site in early spring.

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[1]Schopmeyer's results were based on the gross performance of many operational plantings throughout the northern region--not on designed test comparisons.

Recently, the advisability of fall planting in other western forested regions has been questioned (Stone 1963, 1964; Stone and Benseler 1962; Stone, Schubert, Benseler, and others 1963), but it has also been stoutly defended (Wagener 1964). In the northern Rocky Mountain area, the question continues to be privately debated, with little consensus of opinion. Schopmeyer's results are inadequate for guiding the present-day planting program. More information is needed on Engelmann spruce, Douglas-fir, grand fir (*Abies grandis* (Dougl.) Lindl.), and western larch. Since Schopmeyer published, planting stock production has shifted from the Savenac Nursery in western Montana to the Coeur d'Alene Nursery in Idaho where the growing season is longer and stock can be lifted earlier in the spring. Many nursery practices have changed since the 1910-1937 period on which Schopmeyer based his conclusions. Of particular note was the change to early spring lifting and cold storage of stock, a practice begun at Savenac about 1936. Prior to that time, stock was lifted just ahead of spring planting regardless of its state of dormancy.

The study reported in this paper was designed to evaluate the relative merits of spring and fall planting of Douglas-fir, Engelmann spruce, grand fir, and western larch at high elevations in northern Idaho. In addition to broad comparisons of the performance of spring- and fall-planted trees, we sought further insight by planting at various dates within the fall and spring seasons, on both moist and dry sites.

METHODS

Description of Study Sites

Field planting was done on two areas on the St. Joe National Forest near Avery, Shoshone County, Idaho. Most planting was done at Cougar Creek, about 6 miles south of Avery, at an elevation of approximately 5,000 ft. Here, the north-facing moist site has an average slope of approximately 45 percent. The dry site test on an opposing slope in the same subdrainage has a southwest aspect and a slope of 30 percent. This area was logged in 1965 and burned by wildfire in July of 1966 just before the first fall planting. The original stand was a mixture of Engelmann spruce, western larch, subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), Douglas-fir, lodgepole pine (*Pinus contorta* Dougl. var. *murrayana* (Grev. & Balf.) Engelm.), western white pine, and western redcedar (*Thuja plicata* Donn). The moist, north-facing slope is representative of the *Thuja/Pachistima* habitat type and the drier southwest slope of the *Abies lasiocarpa/Xerophyllum* habitat type (Daubenmire and Daubenmire 1968). On each planting site, there is a residual of standing fire-killed trees. Soils on the Cougar Creek area are derived from quartzitic and argillaceous rock of the Belt series and surface admixtures of loess and volcanic ash.

During the third year of the study, because of lack of space in the Cougar Creek area, planting was shifted southwest 2-1/2 miles to a divide between Sisters and Webfoot Creeks at an elevation of 5,200 ft. Here, the dry site has a south exposure, a 45-percent slope, and the *Abies lasiocarpa/Xerophyllum* type. The moist site has a north exposure, a 50-percent slope, and the *Thuja/Pachistima* type. Soils on both sites are decomposed granites, with surface admixtures of loess and volcanic ash. This area was logged in 1965. The south exposure was slashed and prescribe-burned in 1966. The north slope was treated similarly in 1967. The first and second fall plantings in 1968 were on the Webfoot area, but heavy snows made it necessary to use the Cougar Creek area for the third fall planting. The first and second spring plantings of 1969 were on the Webfoot area, but the third was shifted back to the Cougar Creek area.

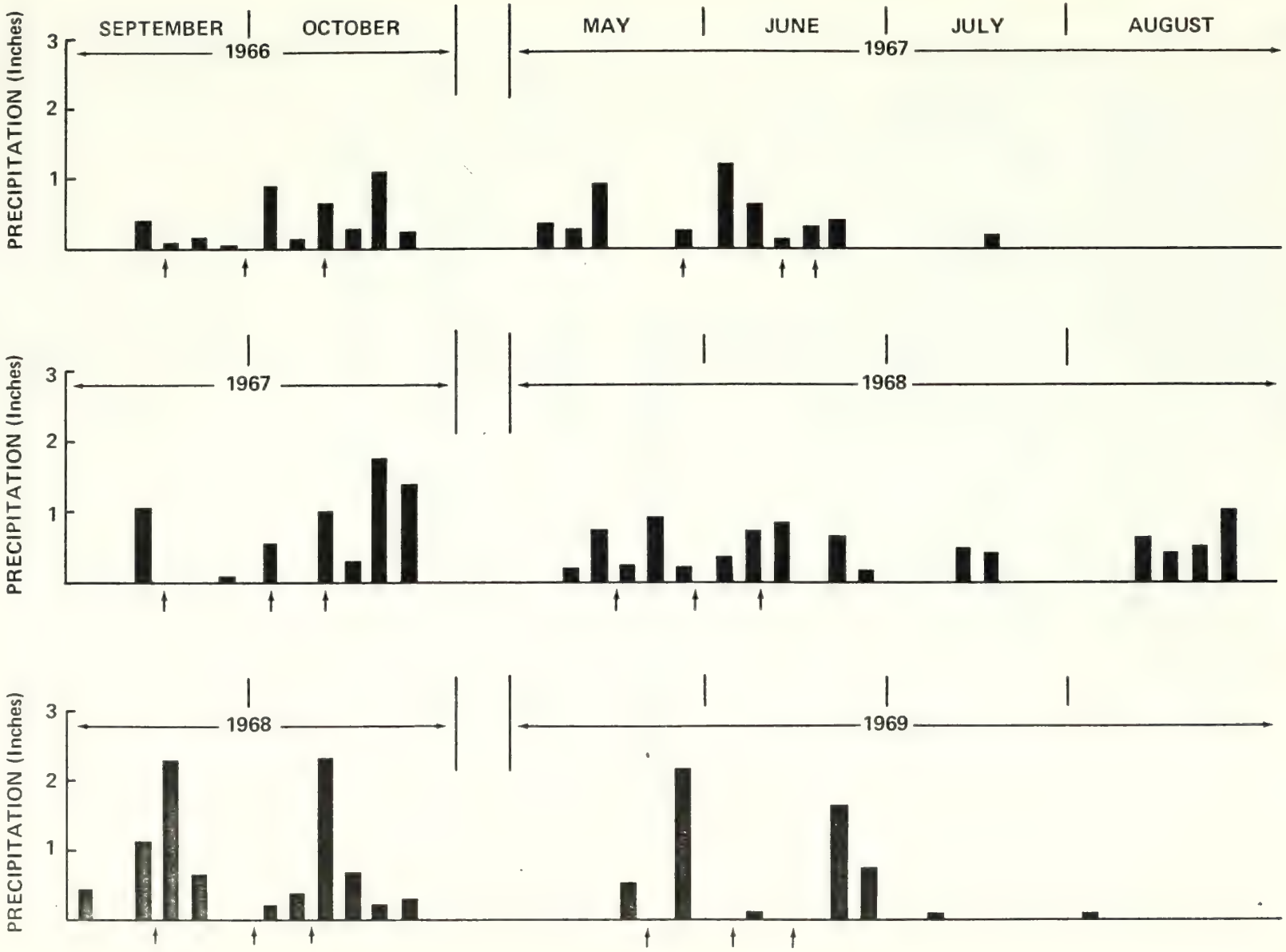

Figure 1. — Five-day precipitation totals at Avery, Idaho, during the study period. Arrows below base lines indicate planting dates.

Planting: Stock and Procedures

Douglas-fir, Engelmann spruce, grand fir (2-0 stock), and western larch (1-0 stock) were planted on each of three dates in the fall and in the spring for 3 successive years. (see figure 1 for specific dates). Fall planting commenced on or about September 15 with successive plantings about October 1 and October 15. Spring planting dates were more variable, beginning as early as May 14 and as late as May 26. Approximately 2 weeks intervened between plantings. Thirty-five trees of each species were planted about 4 ft. apart in adjacent rows up and down the slope. Two replications of the species-row plots were established on each site and planting date.

Fall-planted trees were lifted from the nursery beds and planted within 2 to 3 days. Trees planted in the spring of 1967 and 1968 were lifted early (late March-early April), packed, and stored in the nursery cold storage rooms at 35° F. until just before planting. In the spring of 1969, trees for the first two spring plantings were lifted on May 12 and stored until planting time. Trees for the last spring planting in 1969 were lifted fresh from the nursery beds and planted within 2 or 3 days. Most of the 1969 spring-lifted trees were in some stage of bud burst or shoot elongation when planted.

Special care was taken at all times to avoid heating and drying of the planting stock. Roots were wrapped in wet burlap before placing them in the planting bag. Trees were stored in the shade on the planting site prior to planting and the kraft paper polyethylene bags were kept closed. No drying of the roots was observed.

A short-handled planting bar was used for all planting, which was done either by or under the direct supervision of the senior author.

Measurements and Analysis

Survival was determined for each treatment after the first field growing season. Trees were simply tallied as dead or alive. No attempt was made to determine relative vigor or cause of mortality. No frost heaving or animal damage was observed in any planting.

At the time of planting, soil moisture samples were taken at the 0- to 4-inch level, the 4- to 8-inch level, and the 8- to 12-inch level at three locations within each block. Soil moisture percentages were determined gravimetrically. Moisture retention values at one-third and 15 atmospheres were determined for the 4- to 8-inch soil level.

Statistical design and analysis of the data followed the procedures used in factorial experiments.

ENVIRONMENTAL CONDITIONS DURING THE STUDY PERIOD

Weather Factors

No weather records were kept on the planting site during the study period. Instead, the precipitation and temperature records from the Avery Ranger Station (6 miles north and 2,500 ft. lower in elevation) were used to provide a year-by-year comparison of general conditions similar to those at the planting area (fig. 1).

Weather during the 1966 and 1967 fall plantings was similar, and characterized by relatively sparse precipitation, some rather long dry spells, and high temperatures. By comparison, the 1968 fall planting weather was very moist and temperatures were low. Precipitation during the 1967 and 1968 spring planting seasons was fairly abundant and well distributed. Although abundant, precipitation during the 1969 spring planting season was less uniformly distributed; a 20-day dry spell was recorded from June 1 to 20. Summer weather during the 3-year period was highly variable. The summer of 1967 featured one of the longest and hottest dry spells on record, climaxed by the disastrous Sundance and Trapper Creek forest fires in northern Idaho. The relatively moist summer of 1968 had only one drought, a 23-day period during which less than one-fourth inch of rain fell. The summer drought of 1969 was as severe as that in 1967, but lacked the high temperatures common in 1967.

Soil Moisture

At no time, was the soil moisture in the 4- to 8-inch zone below the wilting point (21 percent) when trees were planted (table 1). Soil moisture content on the moist sites was always 10-40 percent higher than on the dry sites. In general, there was a steady increase in moisture percentage throughout the fall planting season.

Table 1.--*Soil moisture percentage in the 4- 8-inch layer at planting time on moist and dry sites (wilting point, 21 percent; field capacity, 30 percent)*

Year	Site	Fall planting			Spring planting		
		First	Second	Third	First	Second	Third
		- - - - - - - - - - *Soil moisture %* - - - - - - - - - - - - -					
1966-67	Dry	31	29	35	36	40	38
	Moist	43	49	53	52	52	55
1967-68	Dry	26	30	38	35	40	44
	Moist	41	46	55	77	59	64
1968-69	Dry	35	--	41	36	41	30
	Moist	61	--	61	86	59	43

Soil moisture was generally 10 to 20 percent higher in the spring than in the fall and remained relatively stable and abundant throughout the 1967 and 1968 planting seasons. The moisture content declined steadily throughout the 1969 planting season and at the time of the last planting, reached the lowest spring-season value measured during the study period. However, 2.41 inches of rain was measured at Avery from June 21 to June 29, which undoubtedly brought the soil moisture up to field capacity.

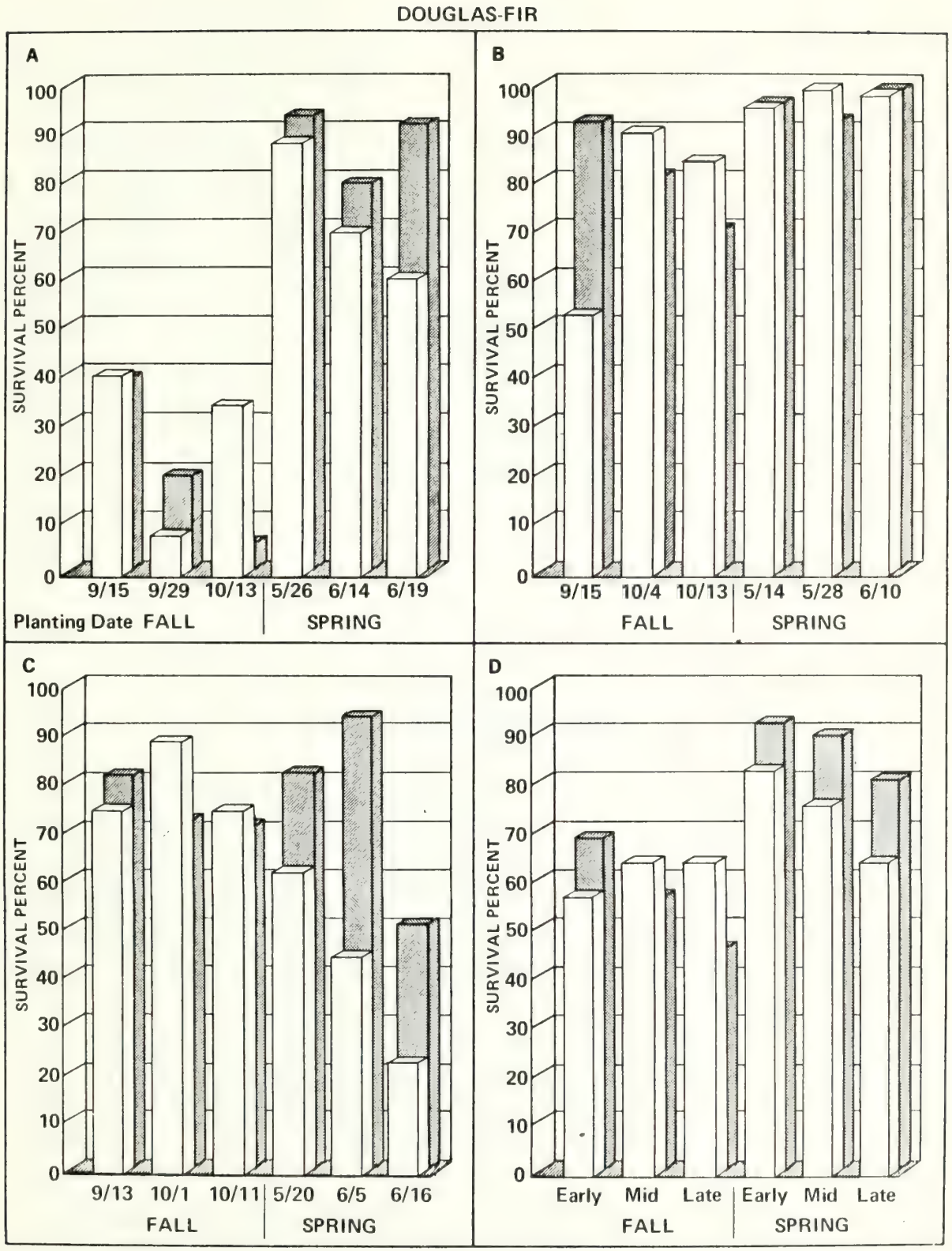

Figure 2. — First-year survival of fall- and spring-planted Douglas-fir, on moist (dark bar) and dry (light bar) sites. A. 1966-67 series; B. 1967-68 series; C. 1968-69 series; and D. 3-year average.

RESULTS

Douglas-fir

For the 3 study years, the average first-year survival of spring-planted Douglas-fir (fig. 2) was 80 percent compared to a survival of 60 percent for fall-planted trees. During the first 2 years of the study, 1967 and 1968, the average differences in percent survival were 57 and 17 percent, respectively, above those of fall plantings. The third year, however, fall plantings survived better than spring plantings by a percentage difference of 17. Undoubtedly, the scarcity of precipitation and attendant low soil moisture (fig. 1) in early June 1969 contributed to the poor performance of these spring plantings. In addition, much of the stock was lifted and planted in a nondormant condition and so was probably predisposed to heavy mortality (see Methods).

Survival of Douglas-fir planted at various times within the fall planting period was highly variable. Survival of the 1966 fall plantings was very poor--below 50 percent--with the early fall planting giving the best results. During the second and third years of the study, all fall-planted Douglas-fir survived well, generally above 70 percent. There was a tendency for survival to decline significantly on moist sites as the planting season progressed, but no significant change in survival was detected for later fall planting dates on dry sites.

Douglas-fir survived well within the spring planting season regardless of planting date, as long as stock was lifted early and stored until planting time. On dry sites, early planting resulted in a tendency (not statistically significant) for better survival; on moist sites, survival seemed to hold up well regardless of planting date.

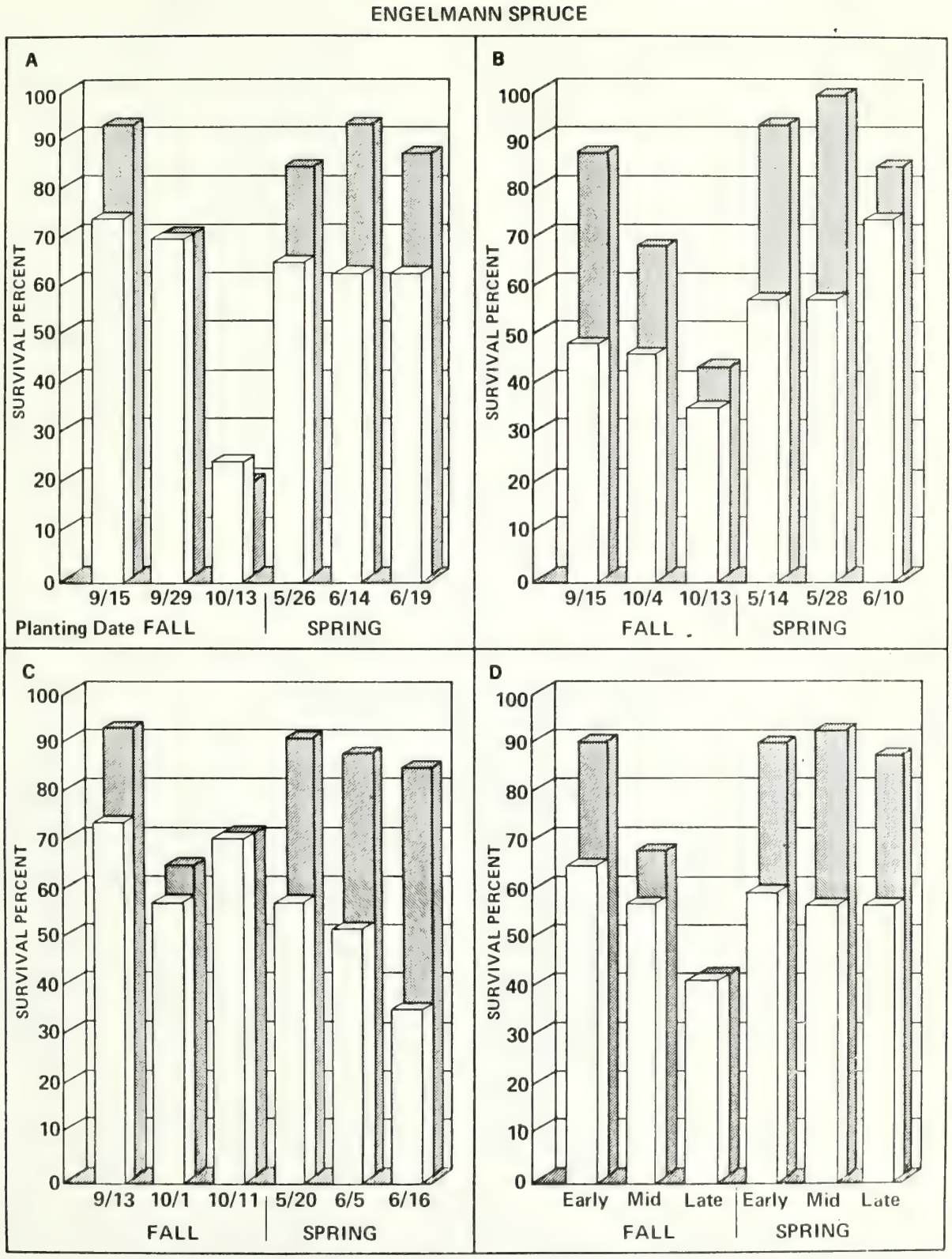

Figure 3. — First-year survival of fall- and spring-planted Engelmann spruce, on moist (dark bar) and dry (light bar) sites. A. 1966-67 series; B. 1967-68 series; C. 1968-69 series; and D. 3-year average.

Engelmann Spruce

The average first-year survival (71 percent) of spring-planted Engelmann spruce (fig. 3) exceeded that (60 percent) of fall-planted trees over the 3-year study period. During the first two test years the differences favored spring planting by fairly wide margins (75 percent compared to 57 percent for the 1966-67 series and 76 percent compared to 52 percent for the 1967-68 series). However, during the third study year survival was good (70 percent) for fall-planted trees, but survival of spring plantings was reduced (67 percent) by a June drought and some nondormant stock.

Survival variations for trees planted during the fall season were large compared to variations for trees planted in the spring. Survival of spruce planted early in the fall on either moist or dry sites was significantly better than that of trees planted later (fig. 3D). For the first 2 years of the study, the survival of spruce declined steadily throughout the fall planting season. In 1968, survival was lower for the midfall planting, but improved slightly for late plantings.

The survival of stock planted within the spring planting season was consistently high and relatively unaffected by lateness of planting. During the 1966-67 and 1967-68 series, survival of spring-planted trees was not reduced appreciably by planting as late as June 19. In the spring of 1969, when some nondormant stock was planted in relatively dry soil, survival decreased as planting was delayed. On the dry site, little difference was recorded between the survival of trees planted in spring or fall (57 percent and 54 percent, respectively). On the moist site, survival was benefited by spring planting (86 percent compared to 63 percent survival for fall planting).

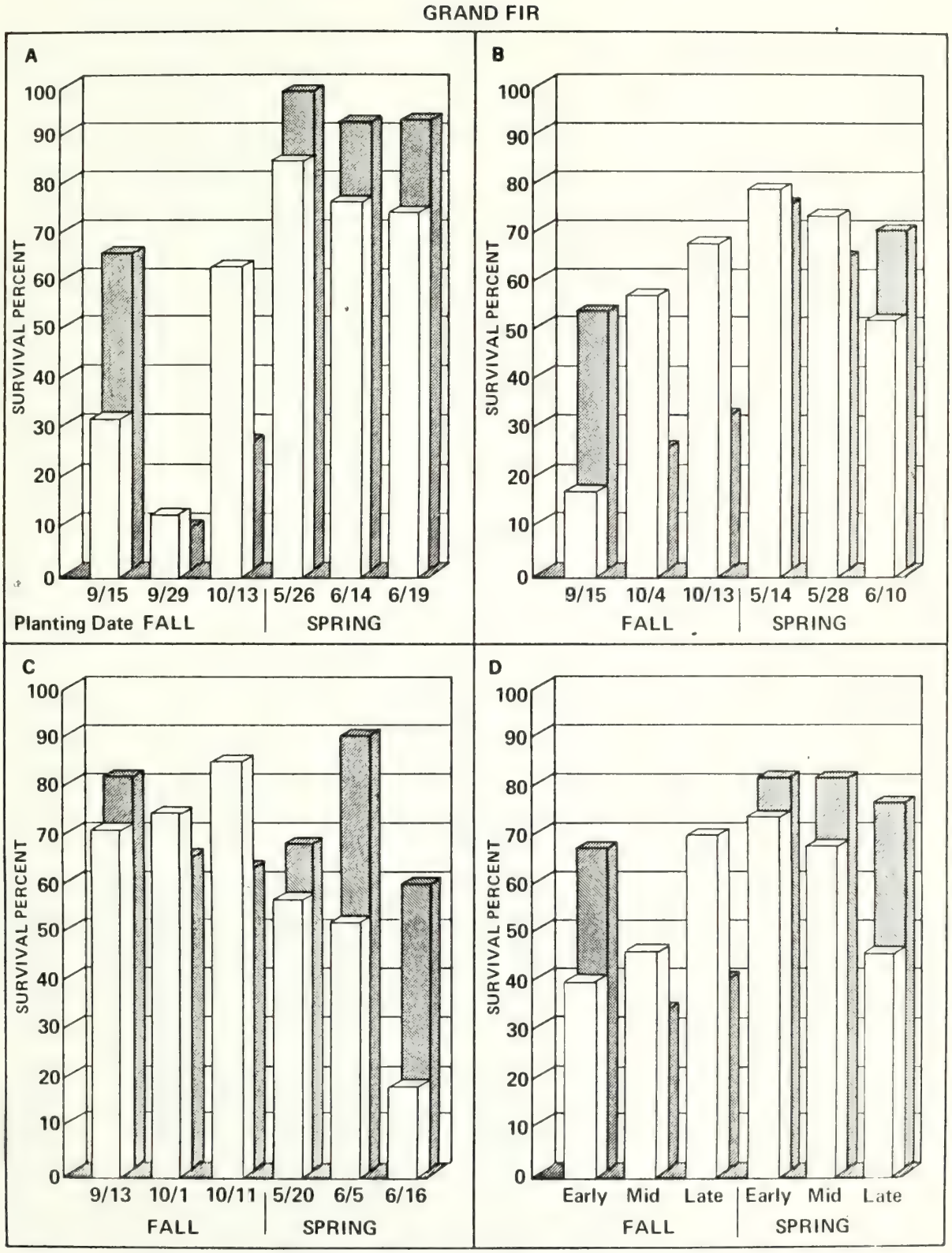

Figure 4. — First-year survival of fall- and spring-planted grand fir, on moist (dark bar) and dry (light bar) sites. A. 1966-67 series; B. 1967-68 series; C. 1968-69 series; and D. 3-year average.

Grand Fir

As was the case with Douglas-fir and Engelmann spruce, the average survival of spring-planted grand fir (fig. 4) was greater for the 1966-67 (86 percent compared to 33 percent) and for the 1967-68 planting (69 percent compared to 41 percent). Fall planting survival was superior in the final study series (72 percent compared to 57 percent). Survival of spring-planted stock was more consistently satisfactory both from the standpoint of year-to-year results and of results recorded during a given planting season.

Survival variations within the fall planting season were great and followed trends similar to but somewhat stronger than those for Douglas-fir. On moist sites, best survival of fall-planted trees was achieved by the early plantings. Survival for trees planted in the middle or late fall decreased significantly. On drier sites, the trend was in the opposite direction, late fall plantings consistently survived better (71 percent) than the early (40 percent) or the midfall (46 percent) plantings. This reverse trend was so pronounced that the dry-site plantings of grand fir in middle and late fall consistently survived better than those on moist sites.

Spring planting of grand fir was consistently satisfactory within the spring planting season, except for the late-season, dry-site planting.

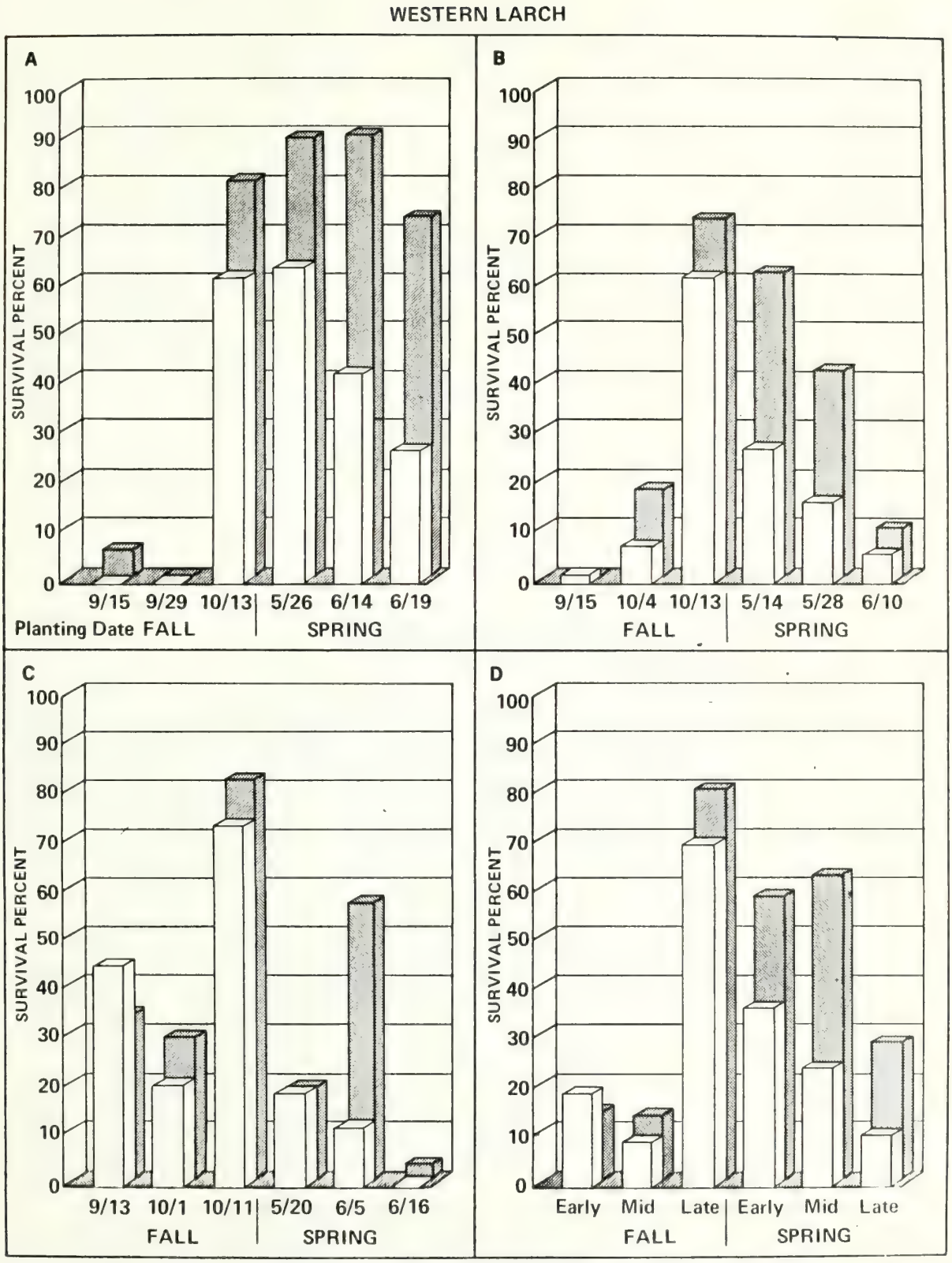

Figure 5. — First-year survival of fall- and spring-planted western larch, on moist (dark bar) and dry (light bar) sites. A. 1966-67 series; B. 1967-68 series; C. 1968-69 series; and D. 3-year average.

Western Larch

Fall- and spring-planted western larch (fig. 5) survived the first growing season about the same in each of the 3 study years (average fall survival 34 percent, average spring survival 37 percent). In the 1966-67 series, the average survival of spring-planted larch was considerably better than that of fall-planted trees (65 percent compared to 24 percent). However, during the second series, trees planted in the spring survived as poorly (28 percent) as those planted in the fall. In the final series, survival of fall-planted larch exceeded that of spring-planted trees (47 percent compared to 17 percent), a margin nearly as great as that in favor of spring planting in the 1966-67 planting series.

The most outstanding feature of the performance of western larch in these tests has been its exceptionally poor survival when planted prior to mid-October (16 percent) compared to its consistently good survival when planted later in the fall season (74 percent). The best average survival for either fall or spring planting resulted from mid-October plantings.

Of all species tested, larch was the most sensitive to lateness of spring planting. Except for the 1967 spring planting on the moist site, survival dropped markedly throughout the spring planting season, especially on the dry habitats. Larch, unlike other species tested, does not store well. It tends to break bud in cold storage. Once the buds break, the foliage becomes chlorotic and a bad mold condition commonly develops.

As was true of other species, differences in survival between dry and moist sites were not as great for fall planting as for spring planting. This feature of the results was further accented by the extremely poor average survival of spring-planted larch in the drier habitat (11 percent).

DISCUSSION

It must be emphasized that 3 years is a small climatic sample from which to draw valid general conclusions or recommendations. On the other hand, 3 years of results obtained under fairly well known study conditions provide a better basis for the comparisons of planting date effects in northern Idaho than was previously possible.

Under the conditions represented in this study, spring plantings have had an overall survival advantage for all species tested. In one of the 3 test years (1968-69), this general advantage shifted slightly from spring to fall planting, which resulted in a nonsignificant F test for the effect of season in the analysis of variance. After an examination of the long-range weather records, we believe that the results for the 1968-69 series of plantings are not in line with normal long-term expectations because of a fortuitous and unusual combination of climatic occurrences. The 1968 fall planting season was unusually moist and cool, which probably contributed to the better overall survival of fall-planted trees (66 percent compared to 42 percent the previous 2 years). In the spring of 1969, the 20-day June drought and attendant low soil moisture undoubtedly contributed to a reduction in the survival of spring-planted trees (50 percent compared to 72 percent in the previous 2 years). Similar, but less severe, spring droughts have occurred in about 6 of the past 30 years. Occurrence of both situations the same planting year must have a low probability. Use of some nondormant stock the spring of 1969 also contributed to reduced survival of spring-planted stock. Therefore, we feel that gross comparisons between fall and spring planting for the first 2 years of the study are probably closer to long-range expectations than comparisons of averages for all 3 years.

Regardless of how it is computed, the average survival advantage of spring planting has been considerably greater in this study than that indicated in earlier comparisons (Schopmeyer 1940). This difference could be attributed to (a) improved handling and consequent better survival of spring-planted stock, (b) average climatic conditions during our study period that did not approximate average climatic conditions during the period from which Schopmeyer's survival averages were compiled, or (c) a narrower base of site conditions in this study compared to Schopmeyer's summary.

While these gross comparisons favor spring over fall planting, the averages for the two seasons can be misleading. Wide variation in survival percentages occurred within the fall planting season. Survival from some fall plantings exceeded average survival from spring planting. Notable were survival percentages for early fall-planted spruce and late fall-planted larch, both of which exceeded the average survival resulting from spring planting by wide and fairly consistent margins. This wide variability of survival results within the fall planting season suggests that much of the performance of fall-planted trees depends upon their physiological condition at time of lifting and planting, as well as the environmental conditions at the planting site. Changes in seedling physiology during the fall season are not visibly as spectacular as those of the spring. Nevertheless, profound changes do occur within the plant as it responds to shortened photoperiods and cooler temperatures and gradually becomes more and more dormant. A 2-week period during this development could bring about physiological changes that would radically alter the ability of the seedling to cope with transplantation and the conditions of a new environment. Add to this the variable and rapidly changing conditions of the planting site environment. The result is an extremely complex set of interactions, which, because of our limited knowledge, defy conclusive explanation.

In contrast to the situation in the fall, spring lifting and planting conditions are somewhat less variable. With the exception of part of the 1969 spring-planted material, stock was lifted prior to any visible bud activity and placed in cold storage until shipped and planted. The cold environment of the stored seedlings tended to inhibit physiological activities of the seedlings and to keep them in a quiescent condition until exposed to the growth-promoting environment of the planting site. Although physiological changes do occur in trees in cold storage, the changes may not be as great as those that take place in the nursery during equivalent time periods in the fall. Thus we feel that our spring-planted trees were more uniform in their physiological condition than the fall-planted seedlings.

The contrast between survival of western larch and that of Engelmann spruce when planted at various times within the fall planting season is noteworthy. Larch could not tolerate lifting and planting until mid-October, but spruce survived best when planted in mid-September. Also, larch continues to grow throughout September at the Coeur d'Alene Nursery, but spruce sets winter buds in late August and early September. The increase in size of larch stock as the fall planting season progressed may have contributed to its better performance, but we feel that physiological changes between October 1 and October 15 made the most significant contribution. Threshold photoperiod or temperature occurring during this period probably triggered dormancy and conditioned the stock so that it could be lifted and planted with minimum physiological disturbance.

As in most coniferous species, the earlier bud set in Engelmann spruce is probably followed by increased root growth, which gradually decreases as the growing season becomes less favorable. Possibly, spruce seedlings that are lifted and planted in mid-September are better able to extend their root systems at the planting site than are those planted later when the fall surge in root-growth activity is declining. A seedling that has been able to extend its root system in the fall probably would have a decided survival advantage through the following growing season and subsequent drought.

The reactions of Douglas-fir and grand fir to planting date within the fall planting period were less pronounced than those of Engelmann spruce and western larch. On the moist sites, both Douglas-fir and grand fir tended to survive best when planted early, as did spruce. On the dry sites, the opposite, larch-like trend seemed to prevail, especially with grand fir. This curious interaction of the effects of planting time and aspect upon survival may result from different environmental factors being limiting on the two aspects. On the northerly aspect, declining soil temperatures may gradually limit fall root growth and reduce the survival potential. In contrast, soil moisture could be the limiting factor on south-facing sites.

CONCLUSIONS AND RECOMMENDATIONS

1. In planting Douglas-fir, grand fir, Engelmann spruce, and western larch throughout the fall and spring planting periods in the northern Rocky Mountains, better survival can probably be expected from planting in the spring.

2. If fall planting is deemed necessary, the land manager is advised to restrict his efforts to drier habitat types typical of southerly exposures. Survival on those sites is apt to compare more favorably with that of spring planting than does that on moist, northerly aspects. In making the choice between fall and spring planting, the land manager should also prorate the cost of gaining access in the spring against the amount of stock to be planted.

3. Western larch should not be fall-lifted and planted before October 15. Unfortunately, this recommendation may prove to be impractical, since planting can be halted by persistent snow cover in northern Idaho mountains soon after this date. Late spring planting of western larch, especially on dry sites, is not recommended.

4. If Engelmann spruce is to be planted in the fall, it should be planted as early as soil moisture conditions permit. Planting later than October 1 could seriously jeopardize results.

5. Although much of the fall planting in this study resulted in satisfactory or acceptable survival rates, our results indicate that equivalent stands can be established at less cost by general spring planting.

6. Fall planting of species mixtures presents special dilemmas. Because of the interaction of species and date within the fall planting period, one cannot expect a given planting date to provide good conditions for all species in a mixture. A mixture of spruce and larch, for instance, would have to be planted in two separate operations to provide reasonable survival of both species. Spring planting would minimize such problems.

7. Under the conditions of this study, restrictions against planting after June 1 seem inappropriate, except for western larch. For Douglas-fir, grand fir, and Engelmann spruce, spring planting of stock stored as long as 11 weeks and planted as late as June 19 gave survival results equal to or slightly less than earlier spring plantings; however, western larch was particularly sensitive to late spring planting, especially on the drier sites. This sensitivity probably resulted largely from the effect of storing on larch, a species that tends to break bud and commence growth under storage conditions that maintain physiological quiescence in the other species studied.

8. When planting must be done during times that have been shown to be less favorable than others, planting rates should be adjusted (if possible) to help provide plantations of desired density.

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1973. Survival comparisons of three fall and spring plantings of four coniferous species in northern Idaho. USDA For. Serv. Res. Pap. INT-139, 20 p., illus. (Intermountain For. and Range Exp. Stn., Ogden, Utah 84401.)

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)