

AN INITIAL DETERMINATION OF THE "LIFTING WINDOW"
FOR PONDEROSA PINE RAISED AT ALBUQUERQUE, NEW MEXICO

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Abstract

In 1980, a study was initiated on six national forests, four in Arizona and two in New Mexico, to determine the "lifting window" for southwestern ponderosa pine seedlings raised at Albuquerque, New Mexico. Seedlings (2-0), raised from seeds collected on the individual forests, were lifted and placed in cold storage monthly from November 1, 1980 to March 1, 1981. Beginning in March 1981, seedlings were planted on the individual forests in the zone from which seeds were collected. Initial results for each forest indicate the later the trees are lifted the higher the survival rate. Trees lifted March 1, had a survival rate of approximately 94% compared to 58% for trees lifted November 1.

Planting is the surest method of establishing ponderosa pine (*Pinus ponderosa* var. *scopulorum*) in the Southwest (Arizona and New Mexico). For planting to be successful, however, healthy seedlings must be planted carefully on well-prepared sites protected from grazing (Heidmann et al. 1977, Schubert et al. 1970). Although past planting efforts have been hindered by the lack of a forest tree nursery in the Southwest, a new Forest Service nursery was established at Albuquerque, N. Mex., in 1977.

One of the first priorities after the establishment of a new nursery is to determine the "lifting window"--the period during which seedlings of a particular source can be lifted with high survival potential. This period, fixed by the seedlings' response to nursery climate and cold storage (Jenkinson and Nelson 1978), is related to the root growth capacity (RGC) of the seedlings at time of planting.¹ The greater the tree's RGC, the greater its chances of survival when planted in the field.

In the Southwest, a species such as ponderosa pine grows over a wide geographic range with varying climatic and edaphic characteristics. The tree ranges from about 5,000 feet (1524 m) in elevation on the Prescott National Forest to nearly 9,000 feet (2743 m) on the North Kaibab. Soils vary from sedimentaries,

¹Jenkinson, James L., and Michel Knight. Seed source and nursery affect growth capacity and field survival of 1-0 ponderosa pine. Unpublished manuscript.

derived from sandstone and limestone, to silt and clay loams originating from basalt parent material. Precipitation patterns differ markedly over relatively small distances. Because of this diversity, it is probably necessary to determine the "lifting window" for each seed source zone in the region.

Study Methods and Materials

A study was begun in 1980 to determine the "lifting window" for ponderosa pine seedlings raised at Albuquerque. Seeds for the study are to be collected in each of four consecutive years from sites representing a diversity of climatic and edaphic factors on six national forests--four in Arizona and two in New Mexico:

| Forest | <u>Approximate</u> | <u>Soil</u> |
|-------------------|----------------------------|-----------------|
| | <u>elevation</u> (feet) | texture |
| Coconino | 7,940 | Silty clay loam |
| Apache-Sitgreaves | 7,350 | Loam |
| Kaibab | 8,250 | Silt loam |
| Tonto | 6,550 | Silt loam |
| Santa Fe | 8,200 | Silt loam |
| Lincoln | 8,000 | Clay loam |

Beginning about November 1, 1980, groups of seedlings were lifted at monthly intervals; for each study site, 10 bundles of 15 plantable trees from that seed source were prepared and placed in polyethylene-lined paper bags. The bags were sealed in cardboard boxes, then stored at approximately 33^o F. (Actual lifting dates varied slightly from the nominal first of the month.)

Seedlings were planted on the various national forests beginning on March 19, 1981 (Table 1) in the same zones from which seeds were collected. The experimental design was a randomized block with 10 replications. Each replication consisted of four plots, 24 by 44 feet. Each of the four plots in a block was randomly assigned to be planted in a different year. Plots to be planted in the spring of 1981 were prepared mechanically in the fall of 1980. On the Apache-Sitgreaves, Tonto, Coconino, and Kaibab National Forests, a small farm disk was used. On the Lincoln plots were prepared by ripping, while on the Santa Fe a rotary tiller was used. Santa Fe plots were not prepared until February 1981--about two months prior to planting.

Each plot consists of 5 rows of 10 seedlings. The five extra trees lifted for each row as a safety factor were discarded. Each row was randomly assigned a different lifting date. Power augers were used to plant trees on all forests except the Kaibab, where rocky soil necessitated the use of planting bars. All of the trees in a replication were planted by one individual except on the Lincoln and Tonto National Forests. Seedlings were planted by personnel from the various Ranger Districts with help from Research.

Seedlings are checked for survival at intervals of 2,4,6,8,12,16, and 20 weeks after planting the first year, and monthly thereafter. In checking survival, trees are classified as:

1. alive and growing
2. alive but not growing
3. dead

From plantation establishment until fall 1981, precipitation information was obtained from the weather station nearest each site. In the fall, rain gages were installed on each area.

Differences in survival were determined by analysis of variance and differences in individual means by Tukey's multiple range test (Table 2).

Results

Initial results from the six plantations were quite similar (Table 1). Mean survival of trees lifted November 1, 1981, was approximately 58% one year after planting, compared with 94% for trees lifted March 1, 1981. The difference in survival between these two dates was greatest on the Lincoln National Forest, and least on the Apache-Sitgreaves.

The trend on all forests is essentially the same. Survival for trees lifted in November was low, then rose dramatically for the December lift. On the Santa Fe, for example, the difference in survival between the two months was 50%. Survival then dropped at the beginning of January, in some cases drastically, then rose to a maximum for the March lift. On all forests except the Lincoln, survival for December-lifted trees was not significantly different from those lifted March 1, while on all forests except the Santa Fe, survival for January-lifted stock was significantly lower than for March.

Discussion

Although the differences between individual months are not always significant, the data suggest there may be three "lifting windows," depending on seed source: late winter peak on the Lincoln, bimodal peaks on the Kaibab, Apache-Sitgreaves, Tonto, and Coconino, and a plateau on the Santa Fe. These results are similar to seasonal patterns in RGC observed by Jenkinson (1980).

He found four distinct patterns: fall peak, winter peak, plateau, and bimodal.

Total precipitation received on all study areas has been excellent. It was generally dry throughout the Southwest prior to study establishment. At about the time that trees were planted, however, significant precipitation fell on all areas. Since then, precipitation has been above normal throughout the region. On the Coconino, for example, over 35 inches of precipitation fell in the 13 months after trees were planted. The yearly normal for the areas is about 22.5 inches. On the Lincoln National Forest about 18 inches of precipitation fell during the first five months of the study.

Most of the mortality in the study appears to be physiological in origin (Table 3). Overall, about 71% of the trees that died did not break dormancy. On four of the forests this figure is over 85%. The remaining mortality is attributed to planting, drought, and miscellaneous factors. Only on the Tonto was drought the leading cause of mortality. The situation is confounded there, however, by planting errors, and the fact that cattle were continually within the study area because of open gates and cut fences. Most trees browsed by wildlife do not die, but a combination of trampling and browsing by livestock can effectively decimate a plantation. On all forests, about onethird of the trees were browsed by wildlife during the first year of the study but very little mortality was attributable to browsing. On the Lincoln, for example, 74 of all trees were browsed during the winter but only a small percentage of the trees died.

The results reflect the diverse character of the region and the variability in southwestern ponderosa pine. In New Mexico, for example, the Lincoln and Santa Fe National Forests are only 200 miles apart and have about the same elevational range. The two forests, however, are entirely different in character. On the Lincoln, moisture is more limiting. Winter moisture is much less dependable and the spring drought begins earlier. Drying winds blowing off the white sands to the west, coupled with drought conditions, make tree establishment difficult. On the other hand, summer storms originating in the Gulf of Mexico begin earlier than on the Santa Fe. Although both forests have mountainous terrain, ponderosa pine on the Lincoln usually grows on steep, rocky slopes with most of the alluvial bottomland in small private farms. On the Santa Fe much of the commercial forest is on mesas and rolling land. Soils are mostly volcanic in origin with a lot of pumice. On the Lincoln soils are more diverse and pumice is lacking.

The different conditions on the two forests helps to explain differences in "lifting windows." On the Lincoln, survival and lifting date show almost a straight-line relationship, while on the Santa Fe, except for November, there is no difference in survival by lifting date. This information suggests that,

because of the harsher conditions on the Lincoln, seedlings must be in optimum physiological condition in order to survive. On the Santa Fe, where conditions are less severe, seedlings may survive even though below their physiological peak. This assumption presupposes that the RGC pattern for both seed lots is increasing throughout the winter and reaches its maximum near the end of the winter season under the environmental conditions at the Albuquerque Nursery. An alternative hypothesis is that the Santa Fe seed source builds to its maximum RGC at Albuquerque in 30 days while it takes about 90 days longer for seed from the Lincoln to reach the same level.

Conclusions

It would be inadvisable to make broad recommendations on when to lift seedlings at Albuquerque based on one year's data. Nevertheless, it seems evident that seedlings should not be lifted in November. Based on the first year's results, the nursery delayed lifting operations in 1982 until February 1. Since the nursery only lifted 1.6 million trees in 1982 this was not a problem. In years when the nursery is in full production, however, it would be difficult logistically to delay lifting that long. If the results from the 1982 planting corroborate the 1981 findings, it appears that lifting could begin for most seed sources on December 1. Santa Fe trees could be lifted continuously from December 1 to March 1, but most of the other seed sources should probably not be lifted in January. It would be advisable to lift Lincoln seedlings no sooner than February 1, and preferably near the end of the month.

Because precipitation was considerably higher than normal throughout the first year of the study, drought was reduced as a cause of mortality. Since most of the differences in survival can then be attributed to lifting dates, the results reported here can be viewed with increased confidence.

Literature Cited

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Table 1. Percentage survival¹ of ponderosa pine seedlings by lifting dates, one year after planting on six National Forests in the Southwest.

| Forest | Date Planted, 1981 | Month lifted | | | | |
|-------------------|--------------------|--------------|--------|-------|--------|-------|
| | | Nov. | Dec. | Jan. | Feb. | March |
| Coconino | April 2 | 57 cd | 79 ab | 68 bc | 76 abc | 95 a |
| Apache-Sitgreaves | April 8 | 71 bcd | 88 ab | 66 d | 87 abc | 96 a |
| Kaibab | April 23 | 72 b | 90 ab | 76 b | 83 ab | 97 a |
| Tonto | March 19 | 61 bc | 75 abc | 51 cd | 89 a | 88 ab |
| Santa Fe | April 15 | 46 b | 96 a | 91 a | 92 a | 96 a |
| Lincoln | March 26 | 40 c | 67 b | 67 b | 80 ab | 91 a |
| Mean | | 57.8 | 82.5 | 69.8 | 84.5 | 93.8 |

¹Differences between means determined using Tukey's multiple range test. Percentages with same letter (within a particular national forest) are not significantly different at the .05 level.

Table 2. Mean squares and F values for first year's results of lifting study for six national forests in the Southwest.

| Forest | <u>Lifting date</u> | | <u>Replications</u> | |
|-------------------|---------------------|----------|---------------------|--------|
| | Mean Square | F | Mean Square | F |
| Coconino | 19.75 | 8.62 ** | 8.10 | 3.54 * |
| Apache-Sitgreaves | 15.83 | 6.85 ** | 2.04 | 0.88 |
| Kaibab | 10.33 | 4.59 ** | 5.68 | 2.52 |
| Tonto | 27.82 | 6.06 ** | 5.74 | 1.25 |
| Santa Fe | 46.12 | 23.77 ** | 2.86 | 1.49 |
| Lincoln | 36.35 | 11.58 ** | 4.23 | 1.35 |

* Significant at .05 level

** Significant at .01 level

Table 3. Percentage mortality attributed to various causes on six study sites in the Southwest during first year of lifting study, and percentage of seedlings browsed by mammals.

| <u>Forest</u> | <u>Cause of First-Year Mortality</u> | | | | |
|-------------------|--------------------------------------|-----------------|----------------|--------------|------------------------------|
| | <u>Physio- logical</u> | <u>Planting</u> | <u>Drought</u> | <u>Other</u> | <u>Seedlings browsed</u> |
| Coconino | 87.7 | 0.0 | 1.8 | 10.5 | 19 |
| Apache-Sitgreaves | 86.0 | 2.3 | 8.1 | 3.5 | 18 |
| Kaibab | 52.8 | 11.1 | 2.8 | 33.3 | 4 |
| Tonto | 20.5 | 26.0 | 38.6 | 15.0 | 32 |
| Santa Fe | 91.4 | 3.4 | 0.0 | 5.2 | 52 |
| Lincoln | 87.0 | 2.7 | 3.4 | 6.9 | 74 |
| Mean | 70.9 | 7.6 | 9.1 | 12.4 | 33 |