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# SPECIES GROWTH CHARACTERISTICS IN A MIXED PINE PLANTATION

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Abstract - A mixed pine plantation of three species can be produced if proper planting and management techniques are used. Nine trees of a species are planted forming an eighteen foot square. Nine such squares will then form a 3 x 3 Latin Square with ample space between species to allow for thinnings and for the development of the slower growing species, resulting in a well developed mixed stand of good quality trees.

## INTRODUCTION

Mixed pine stands of good quality trees can be developed by using a mechanical planting pattern and proper cultural practices. Results of a recent study on Sinnissippi Forest in Ogle County, Illinois, show that in a mixed pine plantation of jack pine Pinus banksiana, white pine Pinus strobus, and red pine Pinus resinosa, it is possible to develop good stocking and good quality for all three species. The competition among these three species is not a problem when the plantation is set up in a proper mechanical planting pattern.

A first thinning at 25 years of age was based on tree spacing, tree form, diameter, crown class, and a residual basal area of 90 square feet per acre. Favoring any given species during this thinning was avoided. Growth characteristics and volume tables for each species were analyzed using the statistical package developed by Nie, Bent, and Hull (1).

## HISTORY

The one-acre study area located on Sinnissippi Forest in Northern Illinois was planted in 1948 with a spacing of 6 feet by 6 feet. The planting pattern illustrated in Figure 1 was designed with each square containing nine trees of a common species. Each nine squares (81 trees) is in the form of a 3 x 3 Latin square repeated throughout the acre.

In 1957 and 1964, 10 and 17 growing seasons after planting, mean diameter and mean height were calculated. The basal area per acre in 1964 for the combined stand was 108 square feet with basal area for jack pine being considerably higher than for either red or white pine (see Table 1).

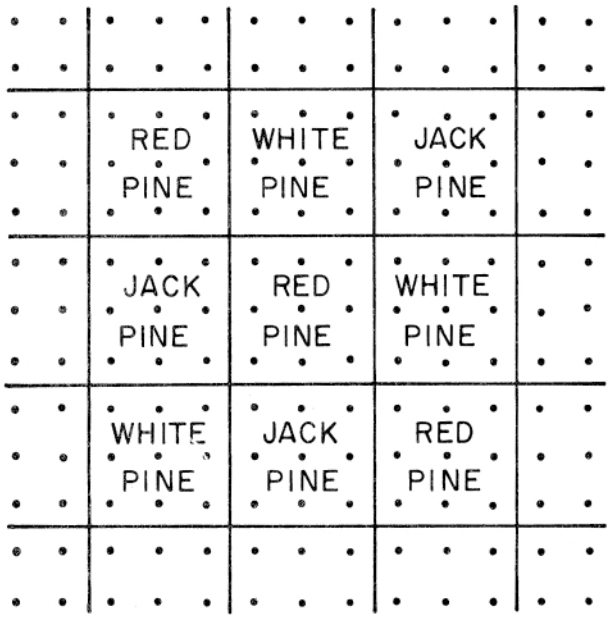


FIGURE 1. CHECKERBOARD ARRANGEMENT OF PLANTATION

The one-acre plantation is on Sparta(2) loamy sand, a deep sand soil that is excessively well drained. A very small corner in the plantation is Jasper(2) soil type which is dark well drained soil with a brownish clay loam subsoil containing sandy loam at depths below 4 feet.

A 0.476 acre study plot consisting of 64 nine tree blocks was established in the center of the 1-acre plantation. In 1973, 25 growing seasons after planting, the study plot was thinned to 90 square feet of basal area per acre. The combined variable formula which expresses tree volume as a linear relationship of $D^2H$[2/] was used for volume computation as described by Spurr (3): $Y = a + bX$; where, Y is equal to volume, "a" is the Y intercept, "b" is the slope coefficient, and X represents $(DIB)^2(H)$[3/]. To determine the regression constants, "a" and "b", 10 trees of white pine, 10 of jack pine and 12 of red pine were drawn at random by diameter classes from the trees marked for thinning. Trees which appeared to have abnormal form were rejected. The measurements to determine volume were taken from the 32 sample trees and a regression equation was thus developed for each species.

Table 1. Development of the 25-year-old stand

| | 1957 | | | 1964 | | | | 1973 | |
|---|---|---|---|---|---|---|---|---|---|
| | DBH | Ht | SURVIVAL | DBH | Ht | BASAL AREA | SURVIVAL | BASAL AREA BEFORE THINNING | SURVIVAL |
| White pine | 1.9" | 13' | 89% | 3.7" | 25' | 25 | 77% | 46 | 68% |
| Red pine | 2.7" | 14' | 95% | 4.3" | 26' | 38 | 95% | 63 | 92% |
| Jack pine | 3.4" | 17' | 94% | 4.7" | 31' | 45 | 94% | 64 | 91% |
| | | | | | | 108 | | 173 | |

In addition to the sample trees, DBH, DIB, and heights were taken from all remaining normal trees marked for thinning. These measurements were then used in the regression equation to establish the volume tables by species.

## RESULTS

Table 2 shows the principal study plot characteristics before and after thinning. Early measurements in the plantation as seen in Table 1 bear out the height and diameter relationships commonly noted among these three species. One can see from Table 2 that these same relationships in height and diameter are still evident among the trees marked for thinning. Jack pine, however, has not been able to maintain the advantage in height and diameter growth as indicated in earlier measurements.

The residual trees appear to show fairly consistent stocking, diameter, and basal area relationships after the commercial thinning.

Volume in red pine is appreciably higher due to the higher stocking and the longer mean merchantable length. The number of trees per acre remaining in

2/ $D^2H$ represents diameter square times height.

3/ $(DIB)^2(H)$ represents diameter inside bark squared timed height.

Table 2. Study plot stand characteristics before and after thinning.

| Species | Before thinning | | | | Cut | | | | Residual | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WP | RP | JP | ALL | WP | RP | JP | ALL | WP | RP | JP | ALL |
| Mean DBH | 5.4 | 5.6 | 5.6 | 5.6 | 4.5 | 5.0 | 5.5 | 5.1 | 6.3 | 6.1 | 5.8 | 6.1 |
| Mean DIB | -- | -- | -- | -- | 4.3 | 4.7 | 5.1 | 4.7 | -- | -- | -- | -- |
| Basal area/acre | 45.64 | 63.13 | 63.63 | 172.4 | 14.88 | 28.83 | 38.68 | 82.4 | 30.76 | 34.30 | 24.95 | 90.0 |
| Mean Merchantable Ht.[1/] | -- | -- | -- | -- | 21.0 | 30.7 | 30.7 | 27.6 | -- | -- | -- | -- |
| Mean Nonmerchantable Ht.[1/] | -- | -- | -- | -- | 15.6 | 11.5 | 13.2 | 13.3 | -- | -- | -- | -- |
| Mean total height | -- | -- | -- | -- | 38.2 | 41.4 | 45.2 | 41.8 | -- | -- | -- | -- |
| Mean cu.ft. volume | 2.87 | 3.51 | 3.47 | 3.32 | 1.95 | 2.85 | 3.31 | 2.82 | 3.77 | 4.30 | 3.75 | 3.96 |
| Number of trees/acre | 269 | 363 | 361 | 993[2/] | 133 | 197 | 225 | 555 | 136 | 166 | 136 | 438 |
| Total cu.ft. volume[3/] | 772.0 | 1274.1 | 1252.7 | 3296.8 | 259.3 | 561.5 | 743.6 | 1565.1 | 512.7 | 713.8 | 510.0 | 1734.5 |

[1/] Sample trees only; 2" minimum top diameter of last stick for merchantable length.
[2/] 1210/acre minus 217 (mortality).
[3/] Discrepancies due to rounding off.

the stand after thinning was 136, 166, and 136 for white, red, and jack pine, respectively.

After plotting the regression equations and fitting the regression lines, a volume table by diameter classes was developed for each species which was used to determine volumes for the residual stand (see Table 3). Data below the line was projected from the regression line.

Table 3. Cubic feet volume inside bark by species and diameter

| DBH | SPECIES White Pine | Red Pine | Jack Pine |
|---|---|---|---|
| 4 | 1.3 | 1.4 | 1.2 |
| 5 | 2.4 | 2.8 | 2.6 |
| 6 | 3.4 | 4.2 | 3.9 |
| 7 | 4.5 | 5.5 | 5.3 |
| 8 | 5.6 | 6.8 | 6.6 |
| 9 | 6.6 | 8.2 | 8.0 |

## STATISTICAL ANALYSIS

The sample data collected yielded the statistical coefficients and regression constants shown in Table 4.

The correlation coefficients for all species approach 1.0, indicating that there is a very good linear relationship between Y and X.

Table 4. Results of the statistical analysis based on 32 sample trees

| Species | No. of trees | Mean and std. error of estimate X: DBH | Y: HT | Y: Vol. | Regression constants X on Y: a | b | Correlation coefficient X on Y |
|---|---|---|---|---|---|---|---|
| White pine | 10 | 4.49 (.425)* | 37.15 (2.029) | 1.95 (.418) | .04999 | .00262 (.00009)* | .99572 |
| Red pine | 12 | 5.52 (.457) | 42.60 (1.175) | 3.64 (.636) | .01618 | .00293 (.00012) | .99107 |
| Jack pine | 10 | 5.61 (.299) | 44.43 (.600) | 3.47 (.405) | .09300 | .00284 (.00022) | .97774 |

* Std. error

Table 5 shows the student's "t" test results at the .05 level of significance. This test is based upon the 32 sample trees. Tests of significance were run as described by Steel and Torrie (4) and Huntsberger (5).

Table 6 shows results after adding a larger number of height and diameter measurements to the sample trees and using the regression equations to obtain volumes. The student's "t" test was used to determine significance between volume means.

It was hypothesized that there is a significant difference in height, DBH, and volume between species thus precluding the possibility of alternate species planting.

## DISCUSSION

The commercial thinning left a residual stand of 90 square feet of basal area per acre, and improved the competitive relationship for white pine. By comparing the mean heights in the "cut" column of Table 2, it appears that the red pine and jack pine would eventually suppress and kill the white pine that are growing immediately adjacent to these species, the average height being considerably less in the white pine. In later years, the jack pine may gradually be eliminated as evidence in the "residual" column indicates. An examination of the residual mean diameters of the three species, suggests that the white pine and red pine mean heights are approaching if not exceeding the mean height of jack pine.

Comparing the residual stand stocking with the stocking before thinning, the residual stand represents 51% of the white pine, 46% of the red pine, and 38% of the jack pine. The high percentage of residual white pine can be traced to the lower stocking before thinning. The stocking before thinning for red and jack pine are consistent, but the residual stocking of jack pine is less than that for red pine. There is a strong indication that the jack pine represents the poorest quality trees. However, as a result of the mechanical planting pattern, a sufficient stocking of quality jack pine was achieved. In fact, this stocking is identical with the white pine. Red pine apparently is the species which is most consistent in growth characteristic qualities.

The volume comparisons between species show white pine to have consistently lower volumes by DBH classes than either red or jack pine (see Table 3). Red pine has the highest volumes by DBH classes. As diameter increases, the range of volume between white pine and jack pine increases. It also increases between white pine and red pine but at a slower rate. As diameter increases, the range of volume decreases between red pine and jack pine. The characteristics in these volume ranges between species can be traced to different form factors for the three species.

It appears that red pine will produce the maximum wood volume for this site. A managed mixed pine plantation on a similar site with the same species will surely sacrifice maximum wood volume.

Table 5. Comparison of height, DBH, and volume differences among species using 32 sample tree

| Species comparison | Total height | DBH | Volume |
|---|---|---|---|
| White pine and red pine | Significant[1/] | Not significant | Not significant |
| Red pine and jack pine | Not significant | Not significant | Significant |
| Jack pine and white pine | Significant | Not significant | Significant |

[1/] Significant at the 0.05 level of confidence using students "t" test.

Table 6. Volume statistics and significance at .05 level

| Species | Number of trees | Mean Volume and std. error of estimate | Volume comparison | .05 |
|---|---|---|---|---|
| White pine | 33 | 1.95 (.187)* | White pine and red pine | Significant |
| Red pine | 60 | 2.85 (.177) | Red pine and jack pine | Significant |
| Jack pine | 57 | 3.31 (.131) | Jack pine and white pine | Significant |

*Std. error.

## CONCLUSION

The residual stocking, diameter, basal area and volume (Table 2) show a much more consistent picture when compared with the cut trees. With 48% of the total basal area removed and 56% of the trees cut during the thinning, all residual trees should respond well until another thinning is necessary in 8 to 10 years.

The next commercial thinning which could produce small sawlogs may necessitate a heavier cut in red pine to maintain a balanced stocking between the three species; otherwise the jack pine stocking would probably be reduced by competition from the red pines. The residual diameter and basal area of jack pine suggest that at the present age of the tree, it may not continue to compete with the other species as in the past.

At this point of plantation development with the usual silvicultural practices performed, the data suggests that a mixed pine plantation of the three species studied can be easily managed to maturity.

The good residual stocking among species appears to be a direct result of the nine tree Latin square blocks established when the plantation was designed.

The question arises as to the possibility of achieving satisfactory results by using a mechanical thinning, such as cutting every other row. It is conceivable that this method would give good results, but this kind of thinning should be done before the plantation is 25 years old. Examination of the tables suggest that at this age too many white pine of inferior quality might be left for the residual stand. This is further evident in view of the higher mortality rate of white pine after 25 years of age. Basal area figures indicate that the plantation could justifiably have been thinned at about 15 years of age. A mechanical thinning at that time could very well have left the plantation with sufficient stocking of all species. The second thinning would unquestionably require the selection method to eliminate the undesirables carried over from the mechanical thinning.

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