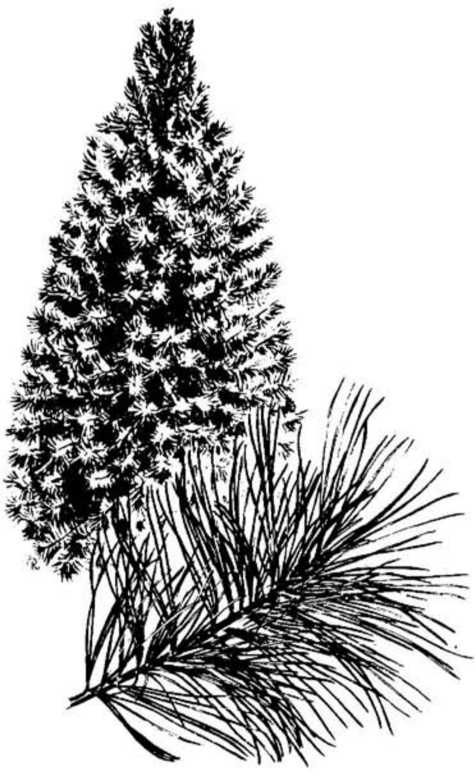
BY RUSSELL S. WALTERS

WHITE PINE PROVENANCES FOR Christmas Trees IN EASTERN KENTUCKY & OHIO



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WHAT SEED SOURCE?

THOUGH EASTERN WHITE PINE is one of the species favored for use as a Christmas tree, little is know about geographic variation within the species, especially in those qualities that are important for Christmas trees—color, form, needle length, needle retention, and growth rate.

The question for a Christmas tree grower in eastern Kentucky and southeastern Ohio is, what seed source will produce the best tree?

In a study of trees grown from seed obtained from 16 regions throughout the natural range of white pine (*Pinus strobus* L.), the best Christmas tree qualities were found in trees grown from seed that came from the Appalachian Mountain regions and from lower Michigan.

BACKGROUND

Eastern white pine has many desirable characteristics for use as a Christmas tree (fig. 1). It is fragrant, has soft blue-green foliage, holds its needles well, and responds well to shearing. It is one of the 10 species used most for Christmas trees (*Sowder 1966*).

For such a specialized use of a tree species, seed source (provenance) is important. Trees grown from seed that comes from

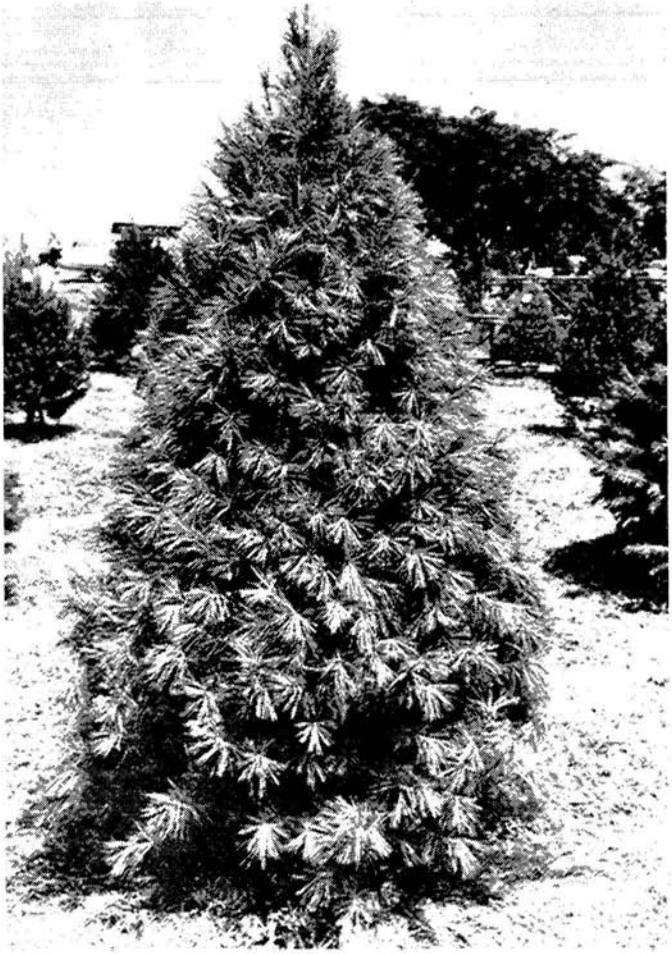


Figure 1. — An 8-year-old plantation-grown eastern white pine that has desirable Christmas tree qualities.

one part of the species' natural range may be different from trees grown from seed that comes from another part of the natural range.

In 1955 the Northeastern Forest Experiment Station began a cooperative study of eastern white pine provenances. Seed was collected from 16 areas (10 average trees at each) throughout the natural range of white pine—from Minnesota, Ontario, Quebec, and Nova Scotia south to Tennessee, North Carolina, and Georgia (fig. 2 and table 1).

From this seed, seedlings were grown at the Ralph Edwards State Forest Tree Nursery at Morganton, North Carolina, and then were outplanted as 2-year-old stock at a number of places to see how seedlings grown from seeds of each source would behave in these various other places.

Though these plantings were not designed with the idea of growing Christmas trees, the provenance plantings provided an opportunity for studying the trees from different seed sources to determine, at each planting site, which seed sources produced trees with the most desirable Christmas tree qualities.

Two plantations were selected for study, one in Laurel County, Kentucky, and one in Athens County, Ohio. The idea was that the seed sources in these two plantations that produced trees with the best Christmas tree qualities would be the best sources of seed

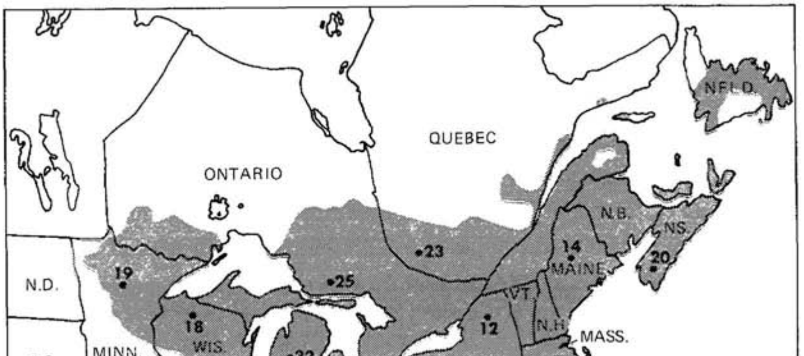


Figure 2.—The range of eastern white pine. The numbers mark the seed sources. The X's mark the experimental plantings in Laurel County, Kentucky, and Athens County, Ohio.

Table 1.—*The eastern white pine provenances studied*

Seed source	Latitude N.	Longitude W.	Elevation, feet
1. Georgia, Union County	34° 46′	84° 03′	2,450
2. North Carolina, Transylvania County	35° 14′	82° 38′	2,120
3. Tennessee, Greene County	36° 00′	82° 48′	2,250
5. West Virginia, Greenbrier County	38° 02′	80° 30′	2,600
6. Pennsylvania, Monroe County	41° 05′	75° 25′	1,800
12. New York, Franklin County	44° 25′	74° 15′	1,600
14. Maine, Penobscot County	44° 51′	68° 38′	150
15. Iowa, Allamakee County	43° 28′	91° 30′	1,000
16. Ohio, Ashland County	40° 45′	82° 15′	1,000
18. Wisconsin, Forest County	45° 51′	88° 54′	1,500
19. Minnesota, Cass County	47° 23′	94° 25′	1,300
20. Nova Scotia, Lunenburg County	44° 25′	64° 35′	150
23. Quebec, Pontiac County	47° 30′	77° —	1,000
25. Ontario, Algoma District	46° 10′	82° 37′	650
30. Virginia, Pulaski County	37° 05′	80° 50′	2,400
32. Michigan, Newaygo County	43° 30′	85° 40′	600

for growing Christmas trees in the general region between and about these two plantations.

STUDY METHODS

In both plantations, the author collected data on foliage color, needle length, needle retention, and height growth. The data were collected in midwinter because it is at this time that needle characteristics are most important for Christmas trees.

For each seed source in both plantations, four trees were sampled. No data were collected from chlorotic or unthrifty trees in either planting. Very few such trees were observed, and no definite trend of this sort could be detected among seed sources.

For measuring needle length, three or four fascicles were collected from the midpoint of the leader of each sample tree. Length was measured to the nearest millimeter .

Needle length is important for Christmas trees because it affects crown density. A tree with a dense crown and long needles usually sells faster than a tree with a thinner crown and shorter needles.

For evaluating needle color, sample needle fascicles from each tree in the plot were stapled to a white card; and a team of two observers rater the color for each seed source.

Color was ranked from dark blue-green—considered the most desirable—to lighter yellowish green.

A two-man panel was considered effective for making color determinations (*Windle and Dingman 1960*). In fact, for many such value judgments a one-man test is considered adequate; for example, for coffee, tea, and wine.

The two people on our panel worked independently, and statistical analysis of their evaluations showed a high correlation. Color perception of both panel members was tested with the Ishihara Standard Color Blindness Test, and both showed normal color perception.

Needle retention was determined by examination of sample trees from each source. Needle retention is important for Christmas trees because it affects crown density. Most white pines in winter have needles both from the current year and one past year. A tree that has needles only from the current year's growth always appears thin, no matter how well shaped or well branched it is. Neither in Kentucky nor Ohio was evidence of partial needle drop observed on those trees retaining 2-year needles.

Tree heights were not measured, because the study plantings had already grown beyond the usual Christmas tree size. However, we had data from measurements made of these plantings at 5 years of age (*Funk 1964*). At 5 years a plantation has usually established its growth pattern; and white pines planted for Christmas trees are expected to be 3 to 3½ feet tall at 5 years.

Of course height growth is important for a Chrismas tree planting. Very slow growth causes a long rotation. Very fast growth is not necessary, because excess growth is removed by shearing anyway.

RESULTS

From the criteria studied, the trees grown from seed from the 16 seed sources were ranked to indicate which seed sources can be expected to produce the best Christmas trees in the eastern Kentucky—southeastern Ohio region.

Foliage Color

The study showed that foliage color can be used for selecting eastern white pine seed sources for use in growing Christmas trees.

Both observers detected green color differences among sources, and their rankings of these sources were associated with color. Further, both observers tended to assign each source to about the same color ranking within each replication. This was determined by correlation analyses computed between observers for their color rankings within each of the 12 Kentucky replications. All but two of the resulting correlation coefficients (r) were significant (table 2).

The 12 groups of color rankings made by each observer for the Kentucky planting were subjected to the Friedman two-way analysis of variance by ranks (Siegel 1956). This indicated a strong association between color ranking and seed source. The probability for each observer was less than 0.1 percent that his consistent ranking of seed sources was due to chance rather than color.

The color-ranking data for the Ohio planting were analyzed in the same way. The probability that the observed ranking arrangement by each observer was due to chance rather than color association was almost 10 percent.

This indicated that each observer found greater color variation among replications of a given source in the Ohio planting than in the Kentucky planting. On the other hand, both observers agreed well in their color ranking of sources within the replications. This

Table 2.—*Correlation coefficients between color ranking by two observers in each of 12 replications in Kentucky*

Replication	Correlation coefficient [1]	Replication	Correlation coefficient [1]
I	0.39	VII	0.81**
II	.52*	VIII	.81**
III	.72**	IX	.86**
IV	.52*	X	.24
V	.87**	XI	.64**
VI	.54*	XII	.86**

[1] * = Significant 5-percent level.
** = Significant 1-percent level.

Table 3.—*Average color ranking of 16 eastern white pine provenances by two observers*

Color [1] rank	Kentucky Observer J	Kentucky Observer R	Ohio Observer J	Ohio Observer R
16	Tennessee	W. Virginia	Ohio	Nova Scotia
15	W. Virginia	Michigan	Nova Scotia	W. Virginia
14	Michigan	N. Carolina	W. Virginia	N. Carolina
13	N. Carolina	[Georgia	N. Carolina	Minnesota
12	Pennsylvania	Tennessee [2]]	Georgia	Ontario
11	Georgia	Virginia	Ontario	Pennsylvania
10	Wisconsin	Pennsylvania	Pennsylvania	Quebec
9	Virginia	Wisconsin	Wisconsin	Maine
8	Ontario	Nova Scotia	[Michigan	[Iowa [2]
7	Ohio	New York	New York [2]]	Michigan]
6	Nova Scotia	Ohio	Virginia	Wisconsin
5	Iowa	Iowa	Iowa	[New York [2]
4	New York	Ontario	Minnesota	Ohio]
3	Maine	Quebec	Tennessee	Tennessee
2	Quebec	Maine	Quebec	Georgia
1	Minnesota	Minnesota	Maine	Virginia

[1] In descending order, from greenest (16) to least green (1).

[2] Brackets indicate tied scores.

was shown by correlation analyses between observers for their rankings in each replication. The correlation coefficients were 0.32, 0.58*, 0.58*, and 0.52*, for each replication respectively. The latter three were significant at the 5-percent level.

The color rankings of the 16 eastern white pine provenances in the Kentucky and Ohio plantings are summarized in table 3. The Kentucky averages are based on observations from 12 replications by each observer and the Ohio averages from 4 by each observer.

To determine if there was a color association among observers and locations, these average color rankings were also subjected to the Friedman analysis. The association indicated by this analysis is good; the probability of this arrangement by chance is less than 2 percent. This means that there are differences in color among the provenances and that these can be detected. The same sources were consistently ranked as more green and others as less green by both observers in both plantations.

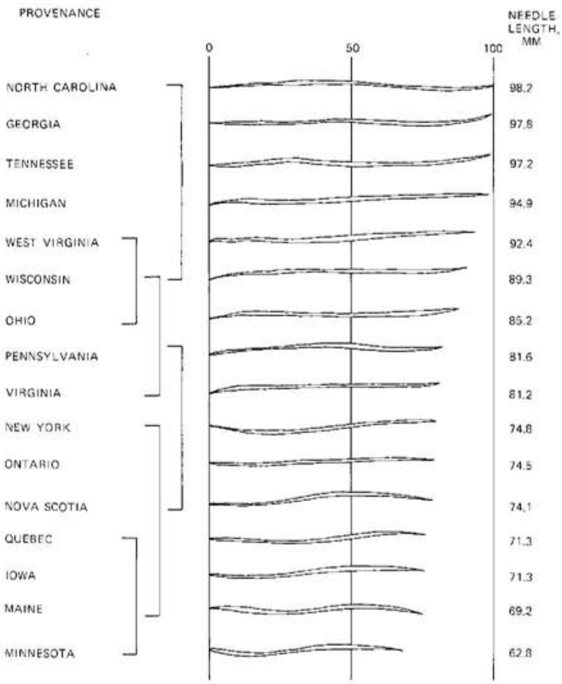


Figure 3.—Average white pine needle length in the Kentucky planting, by provenances. Brackets mark provenances not significantly different in needle length.

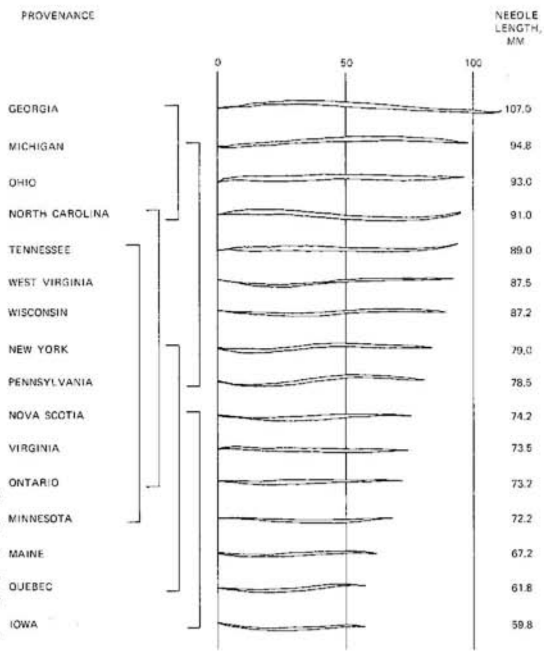


Figure 4.—Average white pine needle length in the Ohio planting, by provenances. Brackets mark provenances not significantly different in needle length.

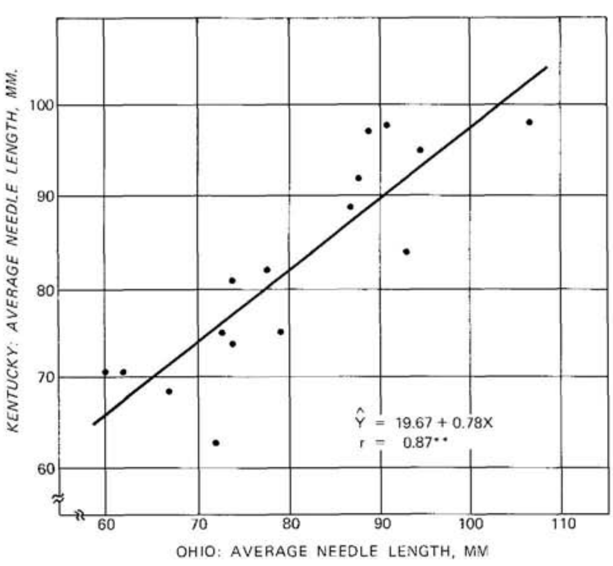
Needle Length

Considerable variability in needle length was found among seed sources (fig. 3 and fig. 4). In the Ohio planting, the longest needles measured were from Georgia trees, and the shortest were from Iowa trees. The Georgia needles were 107.0 mm. long and were 79 percent longer than the Iowa needles, which were 59.8 mm. long. In the Kentucky planting, the longest needles were those of the North Carolina trees, 98.2 mm., and the shortest were those from Minnesota trees, 62.8 mm. The North Carolina needles were 56 percent longer than the Minnesota needles.

Analysis of variance showed that the differences among provenances were highly significant (1-percent level) in both the Ohio and Kentucky plantings.

The correlation between average needle lengths for the trees planted in Kentucky and those planted in Ohio was highly significant (fig. 5). This indicates small within-source differences between the two planting sites. The largest difference found was only 11.3 mm., within the Iowa source. Where differences were observed, the trees in Kentucky generally had the longer needles.

Figure 5.—The average needle lengths of 16 eastern white pine provenances planted in Kentucky and Ohio.



NEEDLE RETENTION

During the winter, foliage of most eastern white pines have needles from 2 years, those of the current year plus those of the previous year. Some trees retain only the needles of the current year. No white pines were found with needles of more than two growing seasons (table 4).

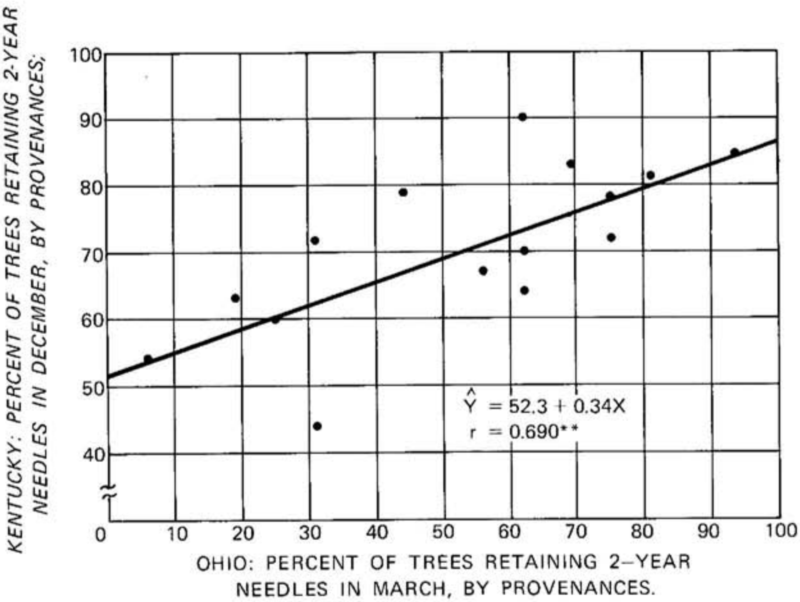
Analysis of variance indicated highly significant differences in average number of years of needle retention among provenances. This was observed in both the Kentucky and Ohio plantings. Furthermore, a correlation analysis (fig. 6) calculated between the percentage of trees retaining 2-year needles was significant at the 1-percent level. Therefore not only were differences found in needle-retention ability among provenances in both the Kentucky and Ohio plantings, but general agreement was found between the two planting sites. Provenances having a large percentage of trees with 2-year needles in one planting also had a large percentage in the other planting.

No one source in either planting was completely uniform. In Kentucky, the highest percentage of trees with 2-year needles was

Table 4.—*Percentage by provenance of eastern white pine trees retaining two seasons' needles*

Kentucky		Ohio	
Provenance	Percent	Provenance	Percent
Pennsylvania	90	Ohio	94
Ohio	85	Georgia	81
Tennessee	83	Michigan	75
Georgia	81	W. Virginia	75
Nova Scotia	79	Tennessee	69
Michigan	78	Minnesota	62
New York	72	N. Carolina	62
W. Virginia	72	Pennsylvania	62
N. Carolina	70	Wisconsin	62
Ontario	67	Ontario	56
Wisconsin	64	Nova Scotia	44
Minnesota	64	Maine	31
Quebec	63	New York	31
Virginia	60	Virginia	25
Iowa	54	Quebec	19
Maine	44	Iowa	6

Figure 6.—The percentage of trees retaining 2-year needles, for each of the 16 eastern white pine provenances planted in Kentucky and Ohio.



90 percent, and the lowest was 44 percent. In Ohio, the range was even greater, from 94 to 6 percent. Because of this variation and because of the agreement among sources in needle retention, seed for Christmas trees should be collected only from those eastern white pine provenances that have good needle retention.

Height Growth

The tree-height measurements taken by Funk (*1964*) were used for comparing provenances (fig. 7 and fig. 8). He had measured 15 of the 16 provenances 5 years after planting, but omitted the Michigan trees in his report because they had been planted a year later. For the Michigan trees in the Kentucky plantation we used his measurements at 4 years and projected them to 5 years. But 5-year height measurements had been made for the Michigan source in the Ohio planting, and we used these data.

The trees in the Kentucky planting have grown faster than those in the Ohio planting. However, the order of provenances is similar in both plantations. The white pines from North Carolina, Tennessee, and Georgia were the three tallest in Kentucky. These same three were also the tallest in Ohio, although in a diffrent order.

Hartley's multiple-range test showed that in each plantation the height differences among trees of the top three sources were not significant (*Snedecor 1956*). These three tallest sources where significantly taller in each plantation than the trees from Quebec, New York, Iowa, Maine, and Minnesota.

In the Kentucky planting, nine of the provenances were taller than the arbitrary standard of 3.5 feet, but in the Ohio planting only the Georgia trees surpassed this standard. However, average height of the Tennessee trees was almost as great as the standard and was not significantly different from the Georgia trees. Furthermore, the North Carolina, Pennsylvania, and Ohio trees averaged approximately 3 feet tall; and—although shorter than the Tennessee average—this height difference was not significant and therefore was considered satisfactory. These five tallest provenances in the Ohio planting were also among the six tallest in Kentucky, if the Michigan trees are included.

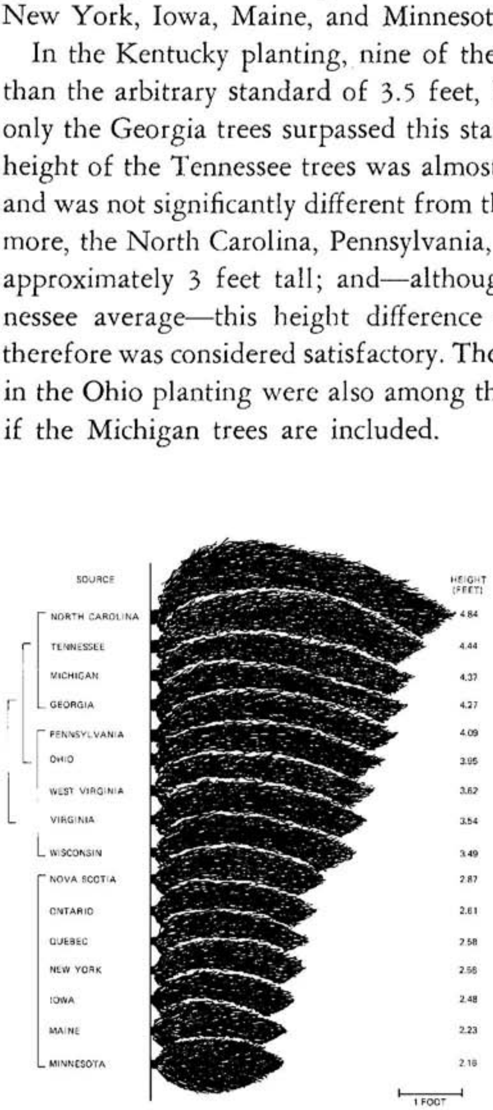


Figure 7.—Average heights of eastern white pine provenances in the Kentucky planting, after 5 years. Brackets mark provenances not significantly different in height growth.

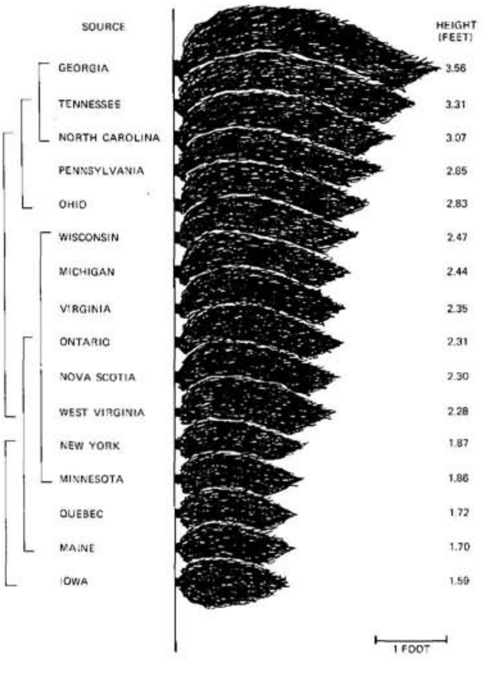


Figure 8.—Average heights of eastern white pine provenances in the Ohio planting, after 5 years. Brackets mark provenances not significantly different in height growth.

Seed Source Rank

A weighted rank for each seed source was determined by combining the rankings for all the criteria studied (tables 5 and 6). The general rankings were as follows, from best to poorest:

Rank	*Kentucky planting*	*Ohio planting*
16	Tennessee	Georgia
15	Michigan	Ohio
14	North Carolina	North Carolina
13	Georgia	Michigan
12	Pennsylvania	West Virginia
11	West Virginia	Pennsylvania
10	Ohio	Tennessee
9	Wisconsin	Wisconsin
8	Nova Scotia	Nova Scotia
7	Virginia	Ontario
6	New York	Minnesota
5	Ontario	New York
4	Quebec	Virginia
3	Iowa	Maine
2	Minnesota	Quebec
1	Maine	Iowa

Table 5.—*Weighted ranking by tree characteristics of 16 eastern white pine provenances planted in Laurel County, Kentucky*

Seed source	Average color rank	Needle length	Needle retention	Height at 5 years	Weighted [1] rank
Tennessee	14	14	14	15	57
Michigan	15	13	11	14	53
North Carolina	13	16	8	16	53
Georgia	11	15	13	13	52
Pennsylvania	12	9	16	12	49
West Virginia	16	12	9	10	47
Ohio	7	10	15	11	43
Wisconsin	10	11	6	8	35
Nova Scotia	8	5	12	7	32
Virginia	9	8	3	9	29
New York	4	7	10	4	25
Ontario	6	6	7	6	25
Quebec	3	4	4	5	16
Iowa	5	3	2	3	13
Minnesota	1	1	5	1	8
Maine	2	2	1	2	7

[1] Sum of numerical rankings for all characteristics.

Table 6.—*Weighted ranking by tree characteristics of 16 eastern white pine provenances planted in Athens County, Ohio*

Seed source	Average color rank	Needle length	Needle retention	Height at 5 years	Weighted [1] rank
Georgia	10	16	15	16	57
Ohio	12	14	16	12	54
North Carolina	14	13	8	14	49
Michigan	8.5	15	14	10	47.5
West Virginia	15	11	13	6	45
Pennsylvania	11	8	11	13	43
Tennessee	2	12	12	15	41
Wisconsin	7	10	9	11	37
Nova Scotia	16	7	6	7	36
Ontario	13	5	7	8	33
Minnesota	8.5	4	10	4	26.5
New York	6	9	5	5	25
Virginia	1	6	3	9	19
Maine	3	3	4	2	12
Quebec	4	2	2	3	11
Iowa	5	1	1	1	8

[1] Sum of numerical rankings for all characteristics.

The average color rankings were developed as averages of the rankings of both observers. The rankings of the individual characteristics were consistent and highly significant. In addition, there was a highly significant correlation between the Kentucky and Ohio rankings.

CONCLUSION

The results from this study indicate that, of the provenances investigated, the white pine seed sources from the southern Appalachian mountains and lower Michigan offer the greatest Christmas tree potential for eastern Kentucky. The Tennessee source tops the list, followed by Michigan, North Carolina, and Georgia.

Three of these four sources are also at the top of the rankings for southeastern Ohio. The Georgia trees rank highest in the Ohio planting, followed by those of Ohio, North Carolina, and Michigan. However, the trees from Michigan were too slow growing after 5 years to be satisfactory for Christmas tree use.

The Tennessee trees ranked high in Kentucky but much lower in Ohio because of very low color rankings by both observers. The results suggest that the Tennessee source loses some of its Christmas tree potential when it is moved northward away from its place of origin, and the Ohio source seems to gain as it is moved closer to its place of origin. In contrast, the Michigan trees ranked higher in the most southerly plantation.

The data indicate that white pine seed to be grown for Christmas trees in eastern Kentucky should come from North Carolina or Georgia. Tennessee and lower Michigan seed sources could also be considered for use in southern Kentucky. Seed of the same sources—except Tennessee—appear to be suitable for southeastern Ohio planting sites. So do seed from the Ohio source.

REFERENCES

Critchfield, William B., and
Elbert L. Little, Jr.
1966. GEOGRAPHIC DISTRIBUTION OF THE PINES OF THE WORLD. USDA Misc. Pub. 991. 97 pp.

Davenport, O. M., and R. S. Walters.
1967. CHRISTMAS TREE CULTURE IN KENTUCKY. Univ. Ky. Agr. Exp. Sta., Misc. Pub. 346. 38 pp., illus. Lexington.

Fowler, P., and C. Heimburger.
1969. GEOGRAPHIC VARIATIONS IN EASTERN WHITE PINE, 7-YEAR RESULTS IN ONTARIO. Silvae Genet. 18(4): 123-129.

Funk, David T.
1964. SOUTHERN APPALACHIAN WHITE PINE OFF TO A GOOD START IN THE MIDWEST. Cent. States Forest Tree Improve. Conf. Proc. 4:26-28.

Genys, John B.
1968. GEOGRAPHIC VARIATION IN EASTERN WHITE PINE (2-YEAR RESULTS OF TESTING RANGE-WIDE COLLECTIONS IN MARYLAND). Silvae Genet. 17(1):1-40.

Ishihara, Shinoba.
[n.d.] ORIGINAL COLOR BLINDNESS TEST CHARTS. 31 pp. Handaya & Co., Tokyo, Japan.

King, James P., and Hans Nienstaedt.
1969. VARIATION IN EASTERN WHITE PINE SEED SOURCES PLANTED IN THE LAKE STATES. Silvae Genet. 18(3): 83-86.

Santamour, F. S., Jr.
1960. SEASONAL GROWTH IN WHITE PINE SEEDLINGS FROM DIFFERENT PROVENANCES. USDA Forest Serv. NE. Forest Exp. Sta. Res. Note 105. 4 pp., illus.

Scott, William A., and
Michael Wertheimer.
1962. INTRODUCTION TO PSYCHOLOGICAL RESEARCH. 445 pp. John Wiley & Sons, Inc., New York and London.

Siegel, Sidney.
1956. NONPARAMETRIC STATISTICS FOR THE BEHAVIORAL SCIENCES. 312 pp. McGraw-Hill Book Co., Inc., New York.

Sluder, Earl R.
1963. A WHITE PINE PROVENANCE STUDY IN THE SOUTHERN APPALACHIANS. USDA Forest Serv. Res. Paper SE-2. 16 pp., illus. SE. Forest Exp. Sta.

Snedecor, George W.
1956. STATISTICAL METHODS APPLIED TO EXPERIMENTS IN AGRICULTURE AND BIOLOGY. Ed. 5, 534 pp., illus. Iowa State College Press, Ames, Iowa.

Sowder, A. A.
1966. CHRISTMAS TREES—THE TRADITION AND THE TRADE. USDA Agr. Inform. Bull. 94. 32 pp.

Windle, Charles D., and
Harvey F. Dingman.
1960. INTERRATER AGREEMENT AND PREDICTIVE VALIDITY. J. Applied Psychol., 44(3):203-204.

Wright, Jonathan W.,
Walter L. Lemmien, and John Bright.
1963. GEOGRAPHIC VARIATION IN EASTERN WHITE PINE—6-YEAR RESULTS. Mich. Agr. Exp. Sta. Quart. Bull. 45(4):691-697, illus.

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