EASTERN WHITE PINE SEED SOURCE VARIATION IN THE NORTHEASTERN UNITED STATES: 16-YEAR RESULTS

Maurice E. Demeritt, Jr., and Harry C. Kettlewood [1]

ABSTRACT.--Twelve eastern white pine (Pious strobus L.) provenance plantations in the northeastern United States were measured for 16-year height and diameter. Differences in height between northern and southern sources have diminished since the 10-year measurements. In general, the 16-year diameter measurements follow the same trends as do the 16-year-height measurements. Recommendations for selection and movement of seed from one region to another are discussed.

In 1955 the USDA Forest Service began a range-wide seed-source study of eastern white pine (Pinus strobus L.) to find the geographic variation in selected traits and to make recommendations for the movement of seed over the species' range. Sixteen-year results for total height and diameter measurements of 29 seed sources in 12 field plantings at 10 locations in the northeastern United States are reported here.

METHODS AND MATERIALS

Cones from 10 trees chosen at random in good stands of natural origin were collected. Cones, seeds, and resulting seedlings were kept separate by parent tree within source through the nursery phase of the study in the Northeast. Seedlings within sources were bulked when lifted from the nursery beds and then were randomly selected for field plots. The location of field plantings and seed-source origins are listed in tables 1 and 2. All seed sources were not represented in every field planting.

Plantations 7 through 11 were established in 1959 with 2-0 seedlings grown in the Maryland State Forest Nursery. Plantations 1 through 4 were established in 1960 with 3-0 seedlings grown in the New Jersey and New York State Forest Nurseries. A detailed description of plantation sites, site preparation, and care has been previously reported (Garrett et al. 1973).

[1] Respectively, Research Plant Geneticist and Forestry Technician, USDA Forest Service, Northeastern Forest Experiment Station, Forestry Sciences Laboratory, Durham, New Hampshire 03824

Table 1.-- Location and design of plantations

Plantation No.	and location	Field design	Latitude	Longitude	Elevation
					(feet)
1	Orono, ME	III	44°53'N	68°39'W	100
2	Alfred, ME	I, II, III	43°32'N	70°40'W	300
3	Essex Junction, VT	III	44°28'N	73°09'W	327
4	Paul Smiths, NY	I	44°26'N	74°13'W	1,815
6	Warren, PA	I	41°50'N	79°15'W	1,180
7	Standing Stone, PA	III	40°37'N	78°55'W	960
8	Kennett Square, PA	I	39°52'N	75°41'W	400
9	Savage River State Forest, MD	III	39°40'N	79°15'W	2,740
10	Horseshoe Run, WV	I	39°11'N	79°35'W	1,720
11	Rison, MD	II	38°30'N	77°20'W	100

Plantations 7 through 11 were established in 1959 with 2-0 seedlings grown in the Maryland State Forest Nursery. Plantations 1 through 6 were established in 1960 with 3-0 seedlings grown in the New Jersey and New York State Forest Nurseries. A detailed description of plantation sites, site preparation, and care has been previously reported (Garrett et al. 1973).

Three field designs, all randomized complete blocks, are represented.

Design I .--One tree from each seed source randomly located in each of 24 blocks at a spacing of 10 by 10 feet.

Design II .--Two-tree-row plots from each seed source randomly located in each of 24 blocks. Seed-source trees were planted at a spacing of 7 feet in rows and 14 feet between seed-source rows. Additional commercial seedlings were planted between seed-source rows to obtain a spacing of 7 by 7 feet.

Design III .--Four-tree-row plots from each seed source randomly located in each of 12 blocks. Seed-source trees were planted at a spacing of 7 feet in rows and 14 feet between seed-source rows. Additional commercial seedlings were planted between seed-source rows to obtain a spacing of 7 by 7 feet.

The additional (nonstudy) trees were removed from all plantations 1 to 3 years before 16-year measurements.

Table 2.-- Seed-source locations for white pine provenance study

Seedlot No.	and location	: Latitude	: Longitude	: Elevation (feet)
1	Union County, GA	34°46'N	84°03'W	2,450
2	Transylvania County, NC	35°14'N	82°38'W	2,120
3	Greene County, TN	36°00'N	82°48'W	2,250
4	Garrett County, MD	39°39'N	78°45'W	2,460
5	Greenbrier County, WV	38°00'N	80°30'W	2,600
6	Monroe County, PA	41°05'N	75°25'W	1,800
7	Monroe County, PA	41°05'N	75°25'W	740
8	Clearfield County, PA	41°00'N	78°30'W	--
9	Clearfield County, PA	41°00'N	78°30'W	--
10	Ulster County, NY	41°45'N	74°15'W	--
11	Ulster County, NY	41°45'N	74°15'W	--
12	Franklin County, NY	44°25'N	74°15'W	1,600
13	Worcester County, MA	42°30'N	72°15'W	1,275
14	Penobscot County, ME	44°51'N	68°38'W	150
15	Allamakee County, IA	43°15'N	91°30'W	1,000
16	Ashland County, OH	40°45'N	82°15'W	1,000
18	Forest County, WI	45°30'N	88°30'W	1,500
19	Cass County, MN	47°30'N	94°30'W	1,300
20	Lunenburg County, Nova Scotia	44°25'N	64°35'W	150
21	Sunbury County, New Brunswick	46°00'N	66°15'W	200
22	Quebec County, Quebec	47°30'N	72°00'W	550
23	Pontiac County, Quebec	47°30'N	77°00'W	1,000
24	Norfolk County, Ontario	42°40'N	80°27'W	750
25	Algoma District, Ontario	46°10'N	82°37'W	650
27	Carroll County, NH	43°45'N	71°25'W	610
28	Lake County, MN	48°00'N	91°45'W	1,300
29	Houghton County, MI	47°00'N	88°30'W	625
30	Pulaski County, VA	37°00'N	80°50'W	2,400
31	Sauk County, WI	43°30'N	89°30'W	1,000

Total height and diameter were measured on each seed-source tree after the 1972 growing season (16 years from seed), except for the three plantations at Alfred, Maine. The Alfred plantations were measured after the 1973 growing season (17 years old), and the data were corrected to 1972.

Analyses of variance for diameter and total height, using plot means, were calculated for each plantation using a least-squares and maximum-likelihood general-purpose program. The program partitioned the total sum of squares into sum of squares for blocks, seed sources, and residual (Block x Seed Source Interaction plus Error).

At each plantation every seed-source mean for height and diameter was divided by the plantation mean and then multiplied by 100. With this statistic we were able to evaluate seed sources across all plantations (tables 3 and 4). It must be noted, however, that increasing height and diameter create a scale effect so equal relative differences do not imply equal actual differences.

RESULTS AND DISCUSSION

Seed-source differences were significant at the 1-percent probability level for total height and diameter at 16 years from seed at all 12 field plantations. This variability in growth traits among seed sources indicate that particular seed sources can be selected for use in certain geographic areas.

Blocks were significantly different at the 1-percent probability level except in plantations 9 and 10. The use of randomized complete block design was efficient at locations where blocks were significantly different because it removed site variation from seed-source variation, which gave us better information on the performance of the seed sources at those locations.

Height Growth

The relative differences in height growth between northern and southern sources of eastern white pine have diminished since the 10-year measurements were made, although actual differences have increased in all plantations (table 3, Garrett *et al.* 1973). At 10 years of age, southern sources were clearly superior. This same trend has been observed in the Central States in measurements at 10 and 15 years, although the magnitude of the relative differences is greater in the Central States (Funk et al. 1975).

In the study reported here, the differences between southern and northern sources were no greater in southern plantations with no or little weeviling (plantations 8 through 11) than they were in northerly plantations with previously good growth but heavy weeviling (plantations 6 and 7). Therefore, the decrease in superiority of southern sources in the Northeast compared to the Central States does not seem to be the result of the white pine weevil (*Pissodes strobi* Peck.) attacking and killing leaders of southern source trees.

Nor is the decreased superiority of southern sources caused by growing-space limitations. The southern-source trees did not grow any taller in Design I plantations at a 10 by 10 foot spacing than they did in Design II and III plantations at a 7 by 7 foot spacing before thinning. It may be that southern-source trees in the Northeast are good early growers, but lose their superiority with time. If this is the case, it will be difficult to evaluate seed sources in provenance tests at an early age.

Table 3.--Height at 16 years from seed of white pine seed-source plantations (seed source mean as percentage of plantation mean)

Seed Source No. and location	Plantation location											
	Cent. Maine 1/	Vt. 3/	N.Y. 4/	S. Maine 2/	S. Maine 3/	S. Maine 1/	N.W. Pa. 6/	Cent. Pa. 7/	S.E. Pa. 8/	W. Md. 9/	W. Va. 10/	S. Md. 11/
1 Georgia	85	107	88	95	89	97	113	118	113	115	110	114
2 North Carolina	89	99	79	94	94	98	102	114	100	106	105	103
3 Tennessee	89	103	99	99	97	103	118	120	120	122	108	121
30 Virginia	--	92	--	105	--	76	--	86	75	--	92	88
5 West Virginia	94	99	99	99	102	100	105	95	104	105	107	99
4 Maryland	86	97	98	101	97	95	107	110	96	115	98	100
16 Ohio	101	104	106	99	98	106	101	101	100	108	96	94
8 Pennsylvania	93	106	108	99	97	106	--	106	101	92	103	98
9 Pennsylvania	114	102	109	105	106	108	117	113	109	116	115	108
6 Pennsylvania	108	105	106	102	101	107	114	106	106	114	109	99
7 Pennsylvania	104	--	96	100	102	102	--	--	--	--	--	--
10 New York	104	103	108	106	103	106	104	113	101	107	102	99
11 New York	118	110	117	107	106	106	105	117	111	112	108	100
13 Massachusetts	110	106	105	108	104	109	109	100	106	104	108	102
24 Ontario	108	110	95	111	108	107	89	115	106	107	112	108
15 Iowa	95	94	99	91	93	94	92	91	95	--	98	95
31 Wisconsin	--	--	--	--	--	--	--	91	105	98	103	106
27 New Hampshire	101	105	--	103	99	108	--	105	107	--	--	109
12 New York	103	103	110	103	102	105	108	101	103	102	99	104
20 Nova Scotia	106	104	95	104	108	103	89	98	100	98	100	101
14 Maine	105	106	111	103	97	101	90	94	93	93	93	95
18 Wisconsin	101	93	103	95	99	97	106	83	95	--	--	92
25 Ontario	108	85	--	93	--	102	89	95	103	89	100	97
21 New Brunswick	99	98	88	97	97	91	100	93	81	84	87	97
29 Michigan	--	--	88	96	93	85	--	85	98	86	93	86
19 Minnesota	99	97	92	97	99	102	103	89	100	100	98	97
22 Quebec	80	86	89	97	84	75	68	74	85	66	78	87
23 Quebec	87	90	--	84	--	95	35	82	86	84	90	81
28 Minnesota	97	94	--	--	--	98	--	91	87	88	92	94
Plantation mean (in feet)	15.7	17.3	14.3	16.8	18.7	19.5	22.2	17.3	20.5	16.1	29.1	26.7

1/ Design III; 2/ Design I; 3/ Design II.

In general, seedlings of southern sources (Georgia, North Carolina, and Tennessee) grew as well as or better than those from most northerly sources in plantations as far north as central Pennsylvania. Garrett et al. (1973) found this same trend for 10-year-height measurements. Faster height growth has also been reported for trees from southern Appalachian sources in the Central States (Funk 1971, Lee 1974, Funk et al. 1975). Sluder and Dorman (1971) found that southern-source trees grew better in North Carolina, Georgia, and Virginia than did those from more northerly sources at 10 years of age. Southern Appalachian sources were no taller than slightly more northerly sources, but were taller than far northern sources at 7 years of age when grown in Ontario (Fowler and Heimburger 1969). Thor (1975) found in a number of tests in Tennessee with a different collection of seed sources that local and southerly sources grew better than more northerly sources from Virginia, West Virginia, and Pennsylvania.

Sources 6 and 9 from Pennsylvania, 11 from New York, 13 from Massachusetts, and 24 from Ontario grew well in all plantations, even when they were moved some distance south from their origin. Garrett et al. (1973) found this same trend for these five sources for 10-year-height measurements.

Responses varied between sources from the same county within a State. Sources 6 and 9 from Pennsylvania grew better at most locations than sources 7 and 8 from the same counties. Also, source 11 from New York grew better at all locations than source 10 from the same county. This indicates that only proven sources from a geographic region should be selected and collected.

The Central States plantations do not have as many of the sources as the Northeast plantations, thus it is difficult to make good comparisons between regions. Some good sources from the Northeast did well in Lower Michigan at age 15 (Lee 1974) and in the Central States (Funk 1971, Funk et al. 1975). Fowler and Heimburger (1969) recommend sources from the Pennsylvania area for planting in Ontario, based on 7-year-height data.

Diameter Growth

At 16 years of age the range of differences in seed-source diameters is equal to or greater than the range of differences in height at each plantation, except the northwestern Pennsylvania plantation (table 4). In general, the ranking of seed sources is the same whether height or diameter is used as the measurement. Wright (1970) found a strong relation between height and diameter at 11 years for 15 sources in southern Michigan.

Table 4.-- Diameter at 16 Years from seed of white pine seed-source plantations (seed source mean as percentage of plantation mean)

Seed source No. and location	Plantation location											
	Cent. Maine 1[1]	Vt. 3[1]	N. Y. 4[2]	S. Maine 2[2]	S. Maine 2[3]	S. Maine 2[1]	N.W. Pa. 6[2]	Cent. Pa. 7[1]	S.E. Pa. 8[2]	W. Md. 9[1]	W. Va. 10[2]	S. Md. 11[3]
1 Georgia	79	112	93	98	91	100	128	136	131	117	132	142
2 North Carolina	79	104	62	92	96	102	97	125	106	100	124	116
3 Tennessee	79	104	92	97	97	108	127	125	131	121	123	143
30 Virginia	--	85	--	105	--	73	--	96	64	--	88	86
5 West Virginia	85	90	96	94	97	99	102	94	103	107	106	104
4 Maryland	79	82	93	97	97	96	109	106	95	120	99	97
16 Ohio	101	109	102	101	101	113	94	98	94	105	97	90
8 Pennsylvania	95	112	108	102	96	104	--	107	99	87	109	101
9 Pennsylvania	115	103	103	109	106	113	124	118	112	120	128	111
6 Pennsylvania	117	112	105	102	104	111	119	114	113	116	120	102
7 Pennsylvania	116	--	91	104	101	97	--	--	--	--	--	--
10 New York	103	109	128	113	105	112	100	114	110	107	103	105
11 New York	120	110	123	109	109	106	102	118	117	116	112	103
13 Massachusetts	115	112	98	113	111	116	112	104	114	103	125	105
24 Ontario	100	115	100	108	109	105	83	122	107	103	119	117
15 Iowa	97	97	101	93	102	92	87	89	100	--	96	87
31 Wisconsin	--	--	--	--	--	--	--	91	107	98	104	108
27 New Hampshire	104	111	--	103	101	109	--	108	111	--	--	130
12 New York	107	105	106	107	103	106	113	93	107	108	98	105
20 Nova Scotia	110	109	96	107	110	100	81	92	92	90	85	92
14 Maine	111	102	109	106	98	101	84	94	88	95	86	88
18 Wisconsin	102	91	113	90	97	100	99	86	87	--	--	77
25 Ontario	113	88	--	94	--	101	84	91	101	96	88	93
21 New Brunswick	104	92	93	95	93	89	94	90	72	85	75	93
29 Michigan	--	--	84	97	90	84	--	80	97	84	81	74
19 Minnesota	98	95	90	99	102	99	95	84	102	97	93	84
22 Quebec	80	81	98	96	76	78	62	71	75	70	65	76
23 Quebec	80	82	--	74	--	87	55	69	74	74	78	69
28 Minnesota	100	92	--	--	--	95	--	79	79	72	79	81
Plantation mean (in inches)	2.70	3.67	3.04	4.21	4.32	4.54	4.64	3.25	4.53	2.98	5.89	4.14

1/ Design III; 2/ Design I; 3/ Design II.

CONCLUSIONS

1. The Georgia source (1) and the Tennessee source (3) should be selected for planting as far north as central Pennsylvania because of their above-average growth in height and diameter.

2. Pennsylvania sources 6 and 9, New York source 11, Massachusetts source 13, and Ontario source 24 should be selected for planting in the United States north and east of central Pennsylvania.

3. Only proven sources within seed-collection zones should be selected for seedling production.

4. Additional fast-growing sources from the regions outlined in conclusions 1 and 2 may be identified and added through further testing of sources.

LITERATURE CITED

Fowler, D. P., and C. Heimburger. 1969. Geographic variation in eastern white pine, 7-year results in Ontario. Silvae Genet. 18 (4):123-129.

Funk D T. 1971. Eastern white pine seed source trials: ten-year results from three midwestern plantations. USDA For. Serv. Res. Note NC-113, 4 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Funk, D. T., R. Allen, and R. D. Williams. 1975. Fifteen-year performance of eastern white pine seed source tests in the lower Ohio Valley. Cent. States For. Tree Improv. Conf. Proc. 9:153-158.

Garrett, P. W., E. J. Schreiner, and H. C. Kettlewood. 1973. Geographic variation of eastern white pine in the Northeast. USDA For. Serv. Res. Pap. NE-274, 14 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Lee, C. H. 1974. Geographic variation of growth and wood properties in eastern white pine--l5-year results. Northeast. For. Tree Improv. Conf. Proc. 21:36-41.

Sluder, E. R., and K. W. Dorman. 1971. Performance in the southern Appalachians of eastern white pine seedlings from different provenances. USDA For. Serv. Res. Pap. SE-90, 11 p. Southeast. For. Exp. Stn., Asheville, N.C.

Thor, E. 1975. White pine from the southern Appalachians. Cent. States For. Tree Improv. Conf. Proc. 9:145-152.

Wright, J. W. 1970. Genetics of eastern white pine. USDA For. Serv. Res. Pap. WO-9, 16 p.