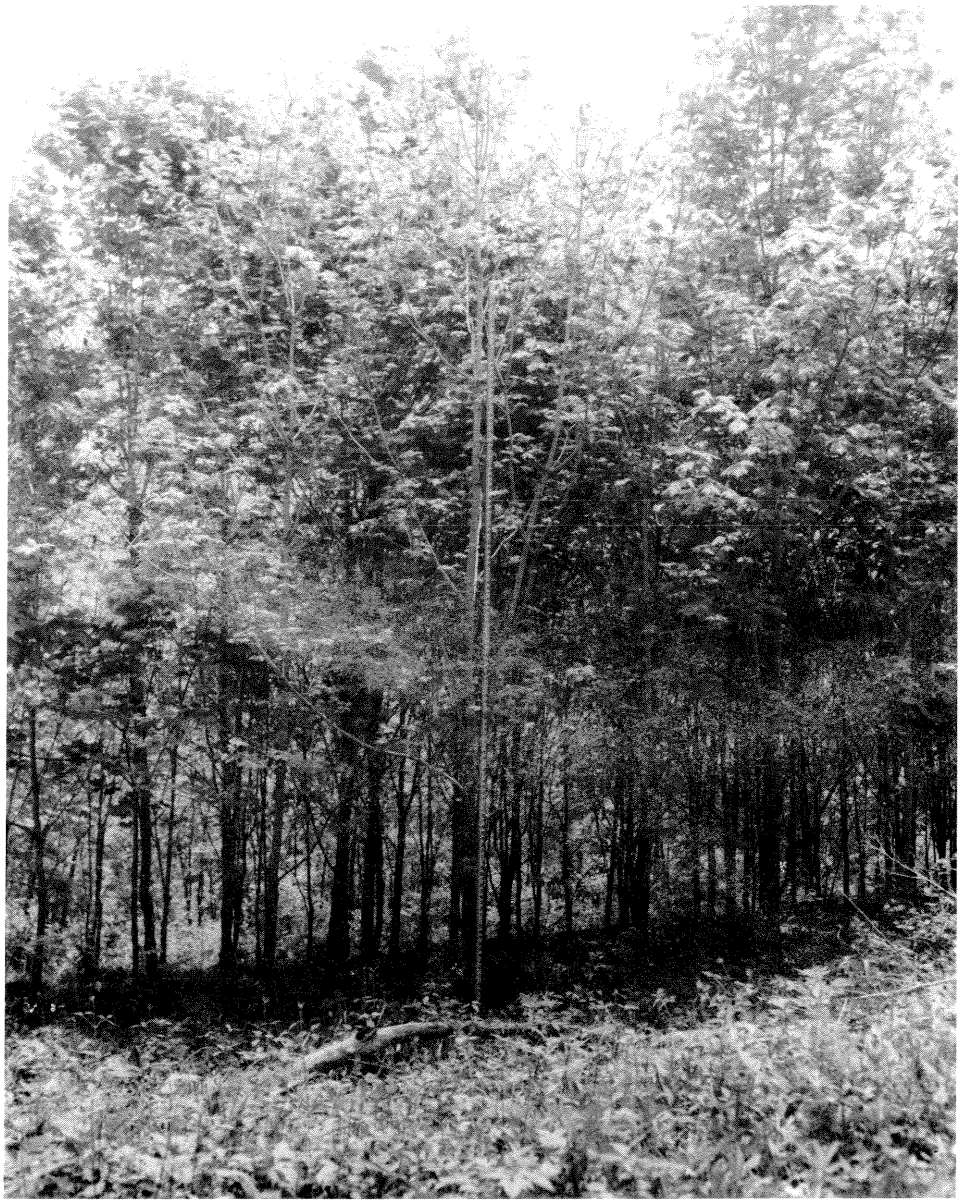
ODC 232.12: 176.1 *Acer saccharum* Marsh.

by G. W. Wendel and W. J. Gabriel

SUGAR MAPLE PROVENANCE STUDY:
West Virginia Outplanting—10-Year Results



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Abstract

After 10 years, survival of sugar maple (*Acer saccharum* Marsh.) provenances outplanted in West Virginia did not differ significantly. Total height, height growth and dbh measurements were significantly different among provenances. Fifty percent of the trees had major forks below 9.0 feet. Thirty-eight percent of the trees had no forks but 71 percent of these were in the intermediate or overtopped crown class. Forking was not related to provenance. Latitude, longitude, and elevation of provenances were not strongly correlated with provenance performance.

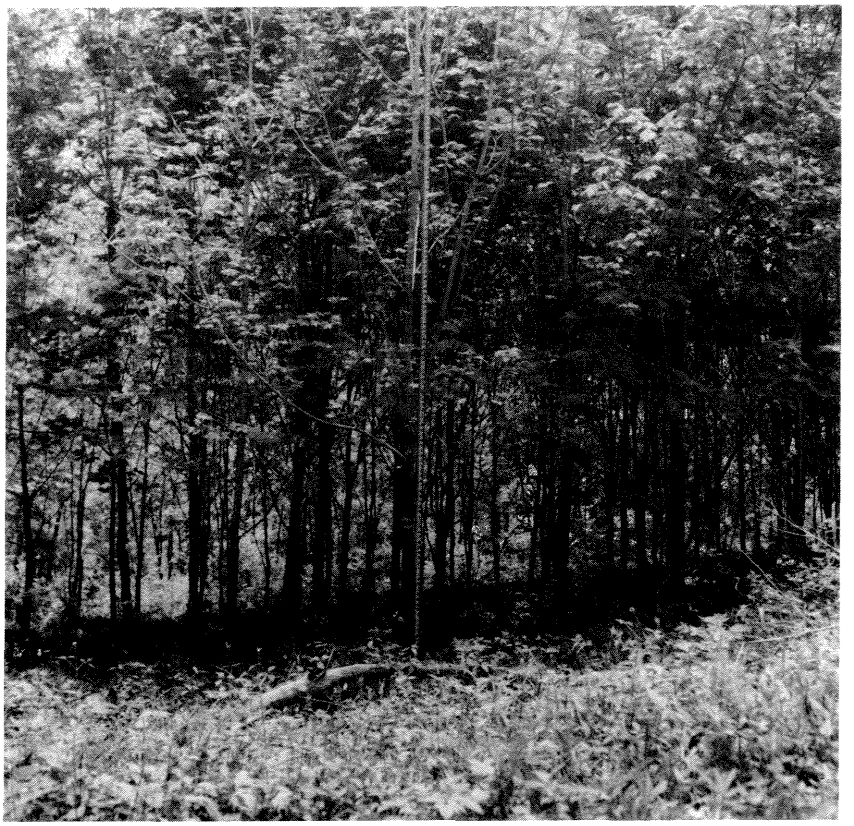
In 1968, a sugar maple provenance study was established on the Fernow Experimental Forest near Parsons, West Virginia. Seeds were collected from seven or eight parent trees in each of 15 provenances except for the West Virginia provenance, which was represented by two wildlings selected on each block. The seedlings were grown for 2 years in a nursery at Burlington, Vermont, and then outplanted at various locations in the Northeast.

The West Virginia outplanting (Fig. 1) was established on a cutover hardwood area at an elevation of 2,800 feet. The area has an easterly aspect and is relatively level (5 percent slope). The soil is DeKalb channery silt loam. Oak site index for the area is 75. Average precipitation on the Fernow Experimental Forest is 58 inches, mean annual temperature is 48° F, and the average growing season is 145 days.

The experimental design is a randomized complete block consisting of five rectangular blocks with their long dimensions parallel with the contour of the study area. Seedlings were planted at a 5- x 5-foot spacing. Each parent-provenance source is represented by a two-tree row plot in each block. During the first 6 years of outplanting, competing vegetation was controlled by hand mowing each summer.

Six-year results were reported by Wendel and Gabriel (1974). This paper reports height, diameter at breast height (dbh), crown position, and height to first major fork measurements taken at 10 years.

Figure 1.—Sugar maple provenance study plantation at 10 years



RESULTS

Survival

Survival averaged 93 percent for the first 10 years. There was no significant difference in survival among blocks or provenances. Except for the West Virginia source, all of the 15 provenances originated from higher latitudes than the planting site (Table 1). Thus, latitudinal differences in survival among provenances have been masked to a certain extent because the elevation of the planting site is 1,200 or more feet higher than the elevation of any of the provenances.

Total height

Average 10-year height for all provenances was 17.6 feet. The tallest trees in the plantation originated from seed collected in Chittenden County, Vermont. They averaged more than 20 feet and were 15 percent taller than the mean for all provenances (Table 2). Average height of trees from the Cass County, Minnesota, seed source was 14.7 feet, the lowest for all sources in the experiment.

The Spearman rank correlation coefficient between the 6-year total height ranking (Wendel and Gabriel 1974) and the 10-year ranking was 0.79. It was significant at the 1 percent level, indicating that the provenances with the tallest trees at 6 years in general have the tallest trees at 10 years. Thus, if we had selected the best performers at 6 years on the basis of total height, our selections at 10 years would be very similar.

There was a significant difference in total height among provenances at 10 years. However, further testing by the Newman-Keuls range test revealed no significant difference among the top nine provenances (Table 2). In contrast, the earlier published results (Wendel and Gabriel 1974) at 6 years showed that the top seven provenances did not differ significantly in total height. These results do indicate that there are possible genetic differences among provenances during the early years and that as time goes on some of the differences begin to fade out. Whether this trend will continue will have to be determined by future measurements.

Within provenance, differences in total height are showing change with time. At the end of six growing seasons, there was a significant difference in average height among progeny of parent trees within eight of the provenances, but at 10 years, average height was significant among families within only four of the provenances. Some of this change came from the death of small, overtopped trees and increased growth on other trees. Thus, trees in certain of the provenances seem better adapted to the outplanting site than others, suggesting genetic variation within provenances.

Table 1.—Sugar maple provenances represented in the West Virginia outplanting

Provenance number	County and state	Latitude	Longitude	Elevation (feet)
15	Ingham Co., Michigan	42° 45′	84° 30′	600-1,400
17	Berkshire Co., Mass.	42° 30′	73° 15′	1,500
18	Sullivan Co., N.H.	43° 27′	72° 23′	400
19	Addison Co., Vt.	43° 55′	72° 50′	900-1,000
20	Lewis Co., N.Y.	44° 00′	75° 23′	900
23	Franklin Co., Maine	44° 00′	70° 08′	560
28	Iron Co., Michigan	46° 15′	88° 33′	1,550
29	Quebec, Canada	46° 45′	71° 00′	350
31	Cass Co., Minn.	47° 15′	94° 30′	1,300
34	Mille Lacs Co., Minn.	46° 03′	93° 40′	1,300
35	Franklin Co., Vt.	44° 48′	72° 57′	600
36	Chittenden Co., Vt.	44° 29′	72° 53′	700-800
37	Rutland Co., Vt.	43° 27′	72° 54′	1,550-1,650
38	Bennington Co., Vt.	42° 57′	73° 10′	900-1,100
39	Tucker Co., W. Va.	39° 04′	79° 40′	2,800

Table 2.—Average total height, average 7- to 10-year height growth, and dbh for all sugar maple provenances

Geographic source	Average total height	Percent of mean height	7- to 10-yr height growth	Percent of mean 7- to 10-yr growth	10-yr dbh	Percent of mean 10-yr dbh
	Feet		*Feet*		*Inches*	
Chittenden Co., Vt.	20.3	115a	8.5	115a	2.2	122a
Lewis Co., N.Y.	19.6	111ab	7.9	107abc	2.1	117ab
Sullivan Co., N.H.	19.1	109ab	8.3	112ab	2.0	111ab
Rutland Co., Vt.	18.9	107ab	8.0	108ab	1.8	100abc
Iron Co., Mich.	18.2	103abc	8.0	108ab	1.7	94abc
Franklin Co., Vt.	18.0	102abc	7.4	100abcd	1.9	106abc
Addison Co., Vt.	17.7	101abc	7.5**	101abcd	1.9	106abc
Berkshire Co., Mass.	17.6	100abc	6.9	93abc	1.9	106abc
Ingham Co., Mich.	17.6	100abc	7.0	95abd	1.8	100abc
Quebec, Canada	17.2*	98bcd	7.2*	97abd	1.8	100abc
Bennington Co., Vt.	17.1*	97bcd	6.7*	91bcd	1.7	94abd
Tucker Co., W.Va.	16.6	94bcd	8.2	111ab	2.0	111ab
Franklin Co., Maine	15.7**	89cd	6.7*	91bcd	1.6	89bc
Mille Lacs Co., Minn.	15.3	87cd	6.4	86cd	1.4	78c
Cass Co., Minn.	14.7*	84d	6.1	82d	1.4	78c
Plantation average	17.6		7.4		1.8	

*Significant within provenance at 5 percent level.
**Significant within provenance at 1 percent level.
Numbers followed by the same letters do not differ significantly at the 5 percent level.

Height growth

The 7- to 10-year average height growth was significant among provenances and ranged from 6.1 to 8.5 feet (Table 2). Average annual growth for the period was 1.9 feet. It ranged from 2.1 feet for the fastest growing provenances to about 1.5 feet for the slowest growing.

The Chittenden County, Vermont, trees averaged 8.5 feet of growth during the 7- to 10-year period and this was about 15 percent better than the mean periodic growth for all provenances. Periodic height growth was lowest for the Cass County, Minnesota, trees (Table 2).

A comparison of provenance ranking by average height growth for the first 6 years of the study and for the current 7- to 10-year period yielded a Spearman's rank correlation coefficient of 0.48, indicating that there has been considerable change in height growth ranking among provenances during the two periods.

That growth differences among families within provenances are becoming less pronounced is evidenced by the fact that there was no significant difference in the 7- to 10-year height growth among 11 of the 15 provenances (Table 2). In 1973 at the end of the first 6 years, average height growth did not differ significantly among families in 8 of the 15 provenances.

Diameter growth

Ten-year average dbh ranged from 1.4 inches to 2.2 inches and averaged 1.8 inches for all provenances (Table 2). Trees originating from the Chittenden County, Vermont, sources averaged 22 percent larger than the mean for all provenances. The smallest trees were from the Cass County and Mille Lacs County, Minnesota, collections.

There was a significant difference in dbh among provenances. The overall diameter spread among provenances was 0.8 inch but for 12 of the 15 provenances, it was only 0.5 inch and these do not differ significantly when tested by the Newman-Keul's multiple range test. Thus, except for the two Minnesota and the Franklin County, Maine, proven-

ances, diameter growth does not differ greatly among provenances. This indicates that sources from most eastern and western parts of the sugar maple range are genetically not as well adapted to the conditions on the planting site as the other provenances.

The Spearman rank correlation coefficient between 10-year dbh and total height was 0.79, indicating that the trees with the largest diameters were also the tallest.

Forking

Many of the trees have major forks; the bole divides to form two stems of about equal height and diameter.

Thirty-eight percent of the trees have good form with no major forking (Table 3). However, 71 percent of these were in the intermediate or overtopped crown class and only 30 percent were dominant or codominant. Fifty percent of the trees had major forks between the ground and 9.0 feet, 12 percent forked between 9.1 and 17.0 feet, and less than 1 percent forked above 17.0 feet.

Forking was not related to provenance. Light browsing and some winter kill during the early years probably contributed to the incidence of forking. The frequent releases during the early life of the plantation may also have encouraged the development of more "bushy" trees. Normally sugar maple comes in as an understory tree and, in this situation, small trees grow slowly and the crowns tend to become sparse and flat-topped. Then, when the trees are released, a new leader assumes dominance and grows up through the flat top forming a straight, single stem (Trimble 1968).

At 10 years, the canopy of the study area is completely closed, and some of the forks may be shaded out. However, corrective pruning will have to be used on a large number of trees if stem quality is to be improved.

SUMMARY

After 10 growing seasons, survival among all provenances is still quite high. However, there are many low-vigor understory trees which will probably die during the next 5 or 10 years. With slightly more than 50 percent of the surviving seedlings in the intermediate and overtopped classes, the process of natural selection is in force and may very well result in the desired plantation density.

There were significant differences in average height, average height growth, and dbh among provenances at 10 years. Many of the differences are small, however, and they do indicate a strong similarity in reaction to the West Virginia environment by most of the provenances represented in the study. On the other hand, trees from the two most western and most eastern provenances were not doing well.

Height growth patterns among provenances have changed considerably with time. Rank correlation analyses showed a nonsignificant correlation between height growth rankings at the end of the first 6 years and the current 4 years, and yet total height correlation between ages 6 and 10 is high. The reason is that the increased growth rates have not yet brought about changes in total height. With this changing situtation, it is still too early to make judgments on provenance superiority.

Table 3.—Distribution of sugar maple trees by height to fork and by dominance class

Height to fork	Dominance Class				All
	Dominant	Codominant	Intermediate	Overtopped	
Feet	*Percent*				
0-9	11	18	10	11	50
9-17	3	5	3	1	12
17-25	<1	—	—	—	<1
No forks	4	7	9	18	38
All	18	30	22	30	100

At 10 years, there do not appear to be any strong correlations between total height or height growth and latitude, longitude, or elevation of parent tree sites. The outplanting site is at an elevation of 2,800 feet which is much higher than any of the provenance locations. Thus, differences among provenances that might have shown up have been masked by the elevation of the study area.

Forking is a problem on most of the study trees. Only 11 percent of the surviving dominant and codominant trees were free of forks. Most sugar maple stands originate from advanced sugar maple when stands are cut. Bushy, miltibranched trees such as many of those in the plantation are seldom found in natural stands. Even though the study trees were closely spaced 5 x 5 feet at planting time, annual releases permitted full sunlight on the trees up to 5 or 6 years. This open development during the early years may have stimulated the development of more bushy, branchy crowns which, in later years, produced the major forks that we are observing.

In general, the surviving dominant and codominant trees appear to be healthy and vigorous. Mortality up through 10 years has been low but, due to the large number of intermediate and overtopped trees in the plantation, we expect that mortality will increase in the next 5 to 10 years.

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