FIFTEEN-YEAR RESULTS OF A LIMITED RANGE EASTERN LARCH SOURCE STUDY 1/

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ABSTRACT -- Seedlings from the NC-51 Eastern larch seed source study were planted on three sites in northern West Virginia. In an earlier report, seventh year results were presented for one of the three plantation. This report includes an evaluation of all three plantings at 15 years of age. The low elevation planting (1100 ft) had very poor survival and no measurements were taken. Results from the two high elevation plantings (2300 ft) are presented and recommendations are made for sources that are suitable for planting in this area.

In previous report (Cech, et al, 1977) we discussed the survival and growth rate of trees from sixteen seed sources growing on one plantation on the West Virginia University Forest. Seedlings for this study were grown from seed collected by Pauley for the NC 51 Regional Project (Pauley, 1964),and the seedlings were made available to the authors by Jonathan Wright at Michigan State University.

Tamarack [*Larix laricina* (Du Roi) K. Koch] has an extensive natural range, occurring widely in the boreal and northern forest regions. It grows as far south as the Cranesville Swamp in West Virginia at an altitude of 2250 feet. Usually, especially in its southern extremes, it is a tree associated with bogs and swamps. In its northern range it grows on drier sites (Roe, 1957).

Pauley's study had for two of its objectives, "to provide information on the range and pattern of genetic diversity in this widely distributed, but little known native species of *Larix*," and "to isolate the best adapted sources for plantation culture and for the establishment of breeding aboreta."

We were also interested in these objectives and in May, 1967 established three small plantations with 16 sources each with the limited number of seedlings available (Table 1). The largest of these was located on the WVU forest at Cooper's Rock State Forest at an elevation of 2300 feet on a relatively flat site, protected on all four sides by a mature cove hardwood stand. The site index for oak is 75. Six replications were planted with four tree linear plots on an 8 by 8 foot spacing.

A second plantation of two replications was established on the WVU Division of Forestry Farm Woodlot located just north of Morgantown at an elevation of 1100 feet on a southeast facing slope, again with four tree linear plots, but on a 6 by 6 foot spacing. Survival on the woodlot site was so poor

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1/ Partially funded by McIntyre Stennis funds.
Published with the approval of the Director of the West Virginia Agriculture and Forestry Experiment Station as Scientific Article #1825 .

that no measurements were ever taken. The site is apparently at an elevation and aspect such that larch was unable to become established. After this plantation was abandoned, the area was overgrown with volunteer species, especially black locust and various shrubs species. In the past year, however we have noticed four or five larch which survived the first years and are now appearing above the understory. These seem to be growing well at this time.

Table 1. Location of Tamarack Seed Source

Source No.	County, State	Latitude (N)	Longitude (W)	Elevation (Ft.)
11	Washington, WI	43°10	88°0	980
12	Washburn, WI	46°0	91°45	1100
13	Carver, MN	45°0	93°45	750
17	Waukesha, WI	43°0	88°15	820
20	St. Louis, MN	47°53	91°51	1421
21	Anoka, MN	45°05	9300	
22	Itasca, MN	47°10	93°28	
24	Richland, WI	43°15	90°20	1000
27	Eau Claire, WI	44°45	91°0	
47	Sawyer, WI	46°0	91°30	1196
50	Van Buren, WI	42°10	86°08	775
52	Cass, MI	41°52	85°57	840
55	Clare, MI	44°0	85°0	
56	Shiawassee, MI	42°49	84°21	
64	Ontario	49°28	82°16	750
65	Kalamazoo, MI	42°23	85°22	840

The third plantation consisting of three replications was established on an open meadow on a southwest facing slope of Mount Zion, approximately 60 miles southeast of Morgantown at an elevation of 2300 feet. Spacing on this plantation was 6 by 8 feet. The plantation on Mount Zion suffered from the exposed site and heavy snowfalls. The small seedlings were twisted and had poor form. Early growth was very slow. The surviving trees have, in general, recovered and are growing well.

The West Virginia University forest and Mount Zion plantations were evaluated in September and October of 1981. Survival, dbh to the nearest 0.1 inch and height to the nearest 0.1 foot were recorded. Measurements were converted to the metric system for analysis. The data were analyzed using a general linear model procedure. Linear regressions were performed using all data in comparison to latitude, longitude, and elevation at the seed source. Correlations between 1973 and 1981 height and diameter measurements were also determined.

Table 2. Height and DBH by source.

Source Number	Location	Average Height + S.D. (cm)	Average DBH ± S.D. (cm)
52	Cass, MI	877 ± 191 a*	10.3 ± 3.4 a
56	Shiawassee, MI	877 ± 204 a	8.7 ± 2.7 abc
21	Anoka, MN	862 ± 209 ab	9.4 ± 2.6 ab
55	Clare, MI	833 ± 203 ab	9.6 ± 3.3 a
24	Richland, WI	818 ± 209 abc	9.6 ± 2.9 ab
11	Washington, WI	817 ± 195 abc	9.0 ± 2.8 abc
50	Van Buren, MI	806 ± 279 abc	9.3 ± 4.2 ab
65	Kalamazoo, MI	786 ± 226 abc	8.8 ± 3.3 abc
22	Itasca, MN	767 ± 195 abc	7.5 ± 2.5 bcd
27	Eau Claire, WI	763 ± 203 abcd	8.6 ± 3.1 abcd
13	Carver, MN	728 ± 223 bcd	7.0 ± 3.0 cde
17	Waukesha, WI	693 ± 219 cd	7.0 ± 3.2 cde
47S	Sawyer, WI	681 ± 242 cd	7.0 ± 3.4 cde
20	St. Louis, MN	679 ± 146 cd	7.2 ± 2.0 cd
12	Washburn, WI	633 ± 168 de	6.5 ± 2.2 de
64	Ontario	513 ± 199 e	5.0 ± 2.8 e

* Values with the same letter are within the same LSD group at the 0.01 level of significance.

RESULTS

The overall average height, dbh, and percent survival were 763 cm (25.0 ft), 8.3 cm (3.3 in), and 68.47, respectively. Differences among sources were significant at the 0.01 level for height and dba (Table 2), and at the 0.05 level for percent survival (Table 4). There was a large variation within sources for height and dbh.

There was a significant inverse correlation of height (r = -0.39547) and dbh (r = -0.48159) to latitude of the seed source at the 0.01 level. Height and dbh were not correlated to either longitude or elevation of the seed source. Survival was not correlated to latitude, longitude, or elevation of the seed source. Height in 1981 was correlated to height in 1973 at the 0.01 level (r = 0.97). Dbh in 1981 was correlated to dbh in 1973 at the 0.01 level (r = 0.89).

Mean height at the WVU Forest (831 cm) was significantly greater at the 0.01 level than mean height at Mt. Zion (577 cm). Average dbh and percent survival at the WVU Forest (8.7 cm and 74.7%, respectively) were significantly greater at the 0.05 level than at Mt. Zion (7.0 cm and 55.3%, respectively). There were no significant site x source interactions for either height or dbh. There were site x source interactions for percent survival at the 0.01 level of significance for 2 sources and at the 0.05 level of significance for 4 sources (Tables 3 and 4).

Table 3. Dbh and total height by source and site.

Accession Number	Source	AVERAGE DBH W.V.0 forest cm	(in)	Mt. Zion cm	(in)	AVERAGE HEIGHT W.V.U. forest cm	(in)	Mt. Zion cm	(in)
52	Cass, MI	10.20	(4.02)	10.70	(4.2)	895	(29.3)	801	(26.3)
21	Anoka, MN	10.0	(3.9)	7.8	(3.1)	947	(31.1)	620	(20.3)
55	Clare, MI	9.9	(3.9)	9.1	(3.6)	919	(30.1)	674	(21.2)
11	Washington, WI	9.8	(3.9)	7.2	(2.8)	908	(29.8)	625	(20.5)
24	Richland, WI	9.7	(3.8)	9.3	(3.7)	883	(29.0)	702	(23.0)
65	Kalamazoo, MI	9.5	(3.7)	6.9	(2.7)	860	(28.2)	564	(18.5)
50	Van Buren, MI	9.4	(3.7)	9.0	(3.5)	888	(29.1)	594	(19.5)
56	Shiawassee, MI	9.2	(3.6)	5.7	(2.2)	927	(30.4)	521	(17.1)
27	Eau Claire, WI	8.9	(3.5)	7.2	(2.8)	806	(26.4)	560	(18.4)
47	Sawyer, WI	8.3	(3.3)	4.0	(1.6)	799	(26.2)	396	(13.0)
17	Waukesha, WI	8.0	(3.1)	5.4	(2.1)	788	(25.9)	527	(17.3)
13	Carver, MN	7.9	(3.1)	4.1	(1.6)	818	(26.8)	456	(15.0)
22	Itasca, MN	7.8	(3.1)	5.9	(2.3)	813	(26.7)	524	(17.2)
20	St. Louis, MN	7.5	(3.0)	6.6	(2.6)	743	(24.4)	550	(18.0)
12	Washburn, WI	7.2	(2.8)	5.3	(2.1)	708	(23.2)	483	(15.8)
64	Ontario	5.3	(2.0)	3.6	(1.4)	547	(17.9)	359	(11.7)
	Mean	8.7		7.0		831		577	

Table 4. Overall survival and survival by site

Source Number	Location	PERCENT SURVIVAL Overall	WVU Forest	Mt.Zion
55	Clare, MI	86.1 a[1/]	83.3	91.7
20	St. Louis, MN	83.3 a	83.3	83.3
11	Washington, WI	77.8 ab	79.2	75.0
24	Richland, WI	77.8 ab	75.0	83.3
22**	Itasca, MN	69.4 abc	87.5	33.3
50	Van Buren, MI	69.4 abc	75.0	58.3
52*	Cass, MI	69.4 abc	83.3	41.7
27*	Eau Claire, WI	69.4 abc	83.3	41.7
12	Washburn, WI	66.7 abc	66.7	66.7
56**	Shiawassee, MI	66.7 abc	87.5	25.0
65	Kalamazoo, MI	66.7 abc	75.0	50.0
17	Waukesha, WI	61.1 bc	58.3	66.7
64*	Ontario	61.1 bc	75.0	33.3
21*	Anoka, MN	58.3 bc	70.8	37.5
13	Carver, MN	55.6 c	62.5	41.7
47	Sawyer, WI	53.1 c	50.0	62.5
	Mean	68.4	74.7	55.3

1/ Values with the same letter are in the same LSD group at the 0.05 level of significance.
* shows a site x source interaction significant at the 0.05 level.
** shows a site x source interaction significant at the 0.01 level.

DISCUSSION AND CONCLUSIONS

Growth and survival were generally good on both sites. In all cases where the same seed sources occurred in both locations, the seedlings grew better in the West Virginia plantings than they did in north-central Wisconsin (Reimenschneider and Jeffers, 1980). The two best sources in the Wisconsin planting (Eau Claire, WI and Anoka, MN) grew and survived well at the WVU Forest, but poorly at Mt. Zion. The Washburn, WI source, which was comparable to the Eau Claire, WI and Anoka, MN sources in Wisconsin, ranked next to last in growth in West Virginia.

Early results of an upper Michigan planting indicate that the results will be similar to those of the West Virginia plantings. Sajdak (1970) reported that the Clare, MI source was tallest, the Waukesha, WI source performed poorly, and that the Ontario source was shortest. These sources had the same ranking for height in West Virginia.

The average height of the four tallest sources at the WVU Forest is 925 cm (2.0 ft/year). The average annual diameter growth of these sources is 0.6 cm (0.25 in/year). This is better growth than for black cherry (1.1 feet/year) (Cech and Carter, 1979), red pine, and white pine planted nearby.

Of the hardwoods, only yellow-poplar could be expected to grow faster (2.3 ft/year and 0.46 in/year, respectively) (Holsoe, 1950).

Although they were not the tallest, the Clare, MI (55) and the Richland, WI (24) sources are recommended for general planting purposes in West Virginia. Both of these sources were above the plantation means for height, dbh, and percent survival on both sites. Therefore, they appear to be less sensitive to site than many of the other sources and will still provide above average wood production. The Cass, MI (52), Anoka, MN (21), and Shiawassee, MI (56) sources will have greater volume than either source 55 or source 24 on good, north-facing, well-protected sites. The performance of the former three sources on poorer sites would be inadequate. The Ontario source should not be planted in West Virginia. With the exception of the Shiawassee, MI source, these recommendations are the same as made in our earlier report on the WVU Forest planting.

Considering the amount of within source variation, further improvement might be obtained by making single tree selections within these seed sources. The correlation of the 1981 growth data to the 1973 data indicates so far that early evaluations are valid indicators of performance, thereby reducing the time necessary to determine the best selections. Since there is a negative correlation of height and dbh due to latitude of the seed source and considering Riemenschneider and Jeffers report of a negative correlation of height to both latitude and longitude of the seed source, the Illinois, Ohio, Pennsylvania, West Virginia, and Maryland sources might also merit investigation.

LITERATURE CITED

Cech, F. C., and K. K. Carter. 1979. GEOGRAPHIC VARIATION IN BLACK CHERRY: TEN YEAR RESULTS. Proc. 1st North Central Tree Imp. Conf., pp. 21-27.

Cech, F. C., R. N. Keys, and D. H. Weingartner. 1976. SEVENTH-YEAR RESULTS OF A TAMARACK PROVENANCE STUDY. Proc. 24th Northeastern For. Tree Imp. Conf., pp. 55-65.

Holsoe, T. 1950. PROFITABLE TREE FORM OF YELLOW-POPLAR. W.Va. Univ. Agric. Exp. Sta. Bull :341.

Pauley, S. S. 1964. SEED SOURCES OF TAMARACK, LARIX LARICINA. Proc. 4th Central States Tree Imp. Conf., pp. 31-34.

Riemenschneider, D. E., and R. M. Jeffers. 1979. HEIGHT AND DIAMETER OF TAMARACK SEED SOURCES IN NORTHERN WISCONSIN. USDA For. Serv. Res. Paper NC-190.

Roe, E. I. 1957. SILVICAL CHARACTERISTICS OF TAMARACK. USDA For. Serv., Lake States For. Exp. Sta., Sta. Paper 52.

Sajdak, R. L. 1969. PROVENANCE TESTING AT MICHIGAN TECHNOLOGICAL UNIVERSITY. Proc. 9th Lake States For. Tree Imp. Conf., pp. 4-5.