



Minnesota Forestry Research Notes

No. 283
April 1983

VARIATION AMONG WHITE SPRUCE PROVENANCES IN MINNESOTA TEST PLANTINGS

Wendy Radsliff, Carl A. Mohn, and William Cromell*

ABSTRACT

Measurements of 25 white spruce seed sources, 15 growing seasons after planting at five locations in Minnesota, revealed substantial effects of source on growth, but not on survival. Above average growth was found for sources from widely dispersed locations in the southern portion of the species range. On the basis of consistently good performance, a Beachberg, Ontario, source (1663) is recommended for use in Minnesota planting programs.

More than 5 million white spruce seedlings are planted each year in Minnesota and indications are that this number will grow. It is clear that the returns from this substantial planting program can be significantly increased by controlling the seed source of the planting stock. Results have indicated that differences in juvenile height growth were strongly associated with origin of seed and that several sources, particularly those from southeastern Ontario, consistently outperform local Minnesota materials (Nienstaedt, 1969; Nienstaedt and Teich, 1972; Stellrecht et al., 1974).

Data collected after 15 growing seasons in five Minnesota test plantings are presented in this note. These data generally confirm previous findings and are reported to serve as a guide in the selection of seed sources for use in Minnesota.

MATERIALS AND METHODS

In the spring of 1962, University scientists, in cooperation with the Forestry Sciences Laboratory, U.S. Forest Service, Rhinelander, Wisconsin, planted five small tests of white spruce seed sources.

Tests contained from 19 to 25 seed sources with 18 common to all plantings. Seeds for the planting stock had been collected in 25 stands at various localities within the natural range of white spruce (Table 1). Most collections contained seed from at least 10 trees. The exceptions were sources 1669 (Minnesota), 1630 (Montana), 1647 (Minnesota), and 1654 (Alaska) which were samples from 6, 5, 2, and 1, respectively.

Seedlings from 24 sources were grown for 2 years at the Hugo-Sauer nursery, Wisconsin, and transplanted to the University's North Central Experiment Station nursery at Grand Rapids, Minnesota, to grow for two additional seasons. The remaining source (3511, Table 1) was 2 - 2 stock grown in the Blandin Paper Company nursery at Grand Rapids from seed collected in that area.

The five tests were planted in randomized complete blocks with 4-tree row plots and five or ten replications. Plantings were surrounded by one or two border rows and spacings varied from 5x5 to 8x8 feet. The locations and specific designs of the plantings are given below.

Plantings were established on old field sites which had been plowed or disked. At Cloquet, clearing and stumping was also necessary. Plantation maintenance included replacement of a number of trees at the Gunn Park, North Branch, and Gibbs Nelson sites in 1963 and 1964, mechanical and chemical control of invading hardwoods at Cloquet between 1971 and 1976 and spraying the Gunn Park planting to limit attacks by the yellow-headed spruce sawfly.

	<u>Plantation</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Nr. Sources</u>	<u>Nr. Reps.</u>	<u>Spacing</u>
1.	Gibbs Nelson	45.0°N	92.5°W	19	5	5' x 5'
2.	North Branch	45.6°N	92.9°W	21	5	8' x 8'
3.	Cloquet	46.8°N	90.7°W	23	5	8' x 8'
4.	Gunn Park	47.2°N	93.5°W	25	10	8' x 8'
5.	Burgeson's Landing	48.1°W	92.8°W	23	5	6' x 6'

*Respectively, Research Assistant and Professor, College of Forestry, and Associate Professor, North Central Experiment Station, University of Minnesota. The authors gratefully acknowledge the planting sites and assistance given by Blandin Paper Company and Diamond Match.

Heights, dbh, and survival of test trees were measured in four plantings in the fall of 1976. At Burgeson's Landing, three of the five replications were lost, probably as the result of a high water table, and the remaining two replications were evaluated for height and survival in August 1977.

Seed source effects on total heights, dbh, and dbh² x height for the first four plantations were examined using standard Analyses of Variance and Duncan's Multiple Range tests at the .05 level of significance. Data from these plantings were evaluated individually by site using plot means. A combined analysis using the means, by plantation, of the 18 sources common to the four plantings was also performed.

Chi-Square was used to test for independence of seed source and survival as of 1976. Replacements were included. Tests were run by plantation considering all sources present. Tests for overall survival included only the 18 sources found in all five plantings. In the analysis of overall survival, the two intact replications at the Burgeson's Landing planting were included.

RESULTS

Survival ranged from 60 to 96% for the five plantations (Table 1). Survival was independent of seed source in individual plantations and when data were combined. High survival was noted in at least one of the plantings for all seed sources. Choice of the seed source was not critical to survival under the conditions tested and ignoring replacements during the first two years.

Growth, like survival, varied greatly from plantation to plantation, reflecting the range of environments tested (Tables 2, 3, and 4). The average tree in the best plantation, Gunn Park, exceeded the average tree in the poorest, Cloquet, by factors of 1.8 for height, 2.3 dbh, and 8.6 for dbh² x height.

Statistically, significant differences in mean source height were found in tests 1-4 (Table 2) and when data were combined. However, the only clear geographic trends were negative correlations between height and latitude (-.55 to -.86). Sources from latitudes north of 50° grew slowly. Rapid growing sources came from widely dispersed locations in the southern part of the species range and supplementary analyses indicated a significant source x planting site interaction.

The statistical separation of source means identified "winners" only in the Gunn Park test where 1663 and 1647 were clearly superior. Although no source was identified by the statistical analysis as the most rapid growing over the range of sites tested, the Ottawa River Valley source, 1663, was substantially taller than other sources when data were combined. Source 1663 ranked first in two tests, second in one test, and fourth in the remaining test. Its performance at Burgeson's Landing was also well above average (Table 2).

Mean diameters and heights of sources were strongly correlated in plantations 1-4 ($r^2 = .76 - .94$). The trends in Table 3 are essentially the same as those for height. Differences among sources in each plantation and when the data were combined were significant. However, as with height, only sources 1663 and 1647 in the Gunn Park test were clearly identified as superior. Source 1663 ranked first in three of the tests and second in the fourth.

Source means for dbh² x height, an index of volume, paralleled those for diameter and height. High latitude sources were generally small and large volumes were associated with collections from widely dispersed stands from New Hampshire in the east to Minnesota in the west. Source 1663 had the greatest value in all but the Cloquet test where it was a close second. At Gunn Park, 1663 was significantly larger than all other sources, and in the combined analysis, sources 1663 and 1647 were significantly larger than all other sources but not different from each other.

CONCLUSIONS AND RECOMMENDATIONS

The relative insensitivity of these tests, particularly the Cloquet and North Branch plantings (see Coefficients of Variation, Tables 2-4), limit the certainty with which conclusions can be drawn. It is clear that high latitude sources grew slowly. No other geographic pattern occurred and seed lots whose growth was well above the average came from widely separated points in the southern portion of the species range, i.e., New Hampshire to Minnesota. The lack of a distinct geographic pattern in growth over a large segment of the white spruce range could be real or the result of limited sampling and large stand-to-stand variation within regions. The data support the suggestion of Nienstaedt (1969) and Nienstaedt and Teich (1972) that the entire southeastern section of the white spruce range be viewed as a potential source of breeding material.

In terms of immediate seed source recommendations for Minnesota, the results have direct implications. First, the overall performance of seed source 1663 (Beachburg, Ontario) justifies the immediate use of it or comparable material in Minnesota planting programs. Volume of this source, as estimated by dbh² x height, was roughly twice that of the average source in the four tests evaluated and 41 and 95% greater than the two Minnesota sources (1647 and 3511) common to all tests. Seed from this source will soon be available from seed orchards established by MINCOTOP.

Secondly, the lack of general trends, indications of substantial variation between stands within limited geographic areas, and the possibility of a seed source x site interaction all suggest that progeny testing be initiated from selected trees within superior stands, and that stand selections be based on tests in the planting zone.

LITERATURE CITED

Nienstaedt, Hans. 1969. White spruce and seed source variation and adaptation to 14 planting sites in northeastern United States and Canada. Comm. Forest Tree Breeding in Canada. Proc. 11:183-194.

Nienstaedt, Hans and Abraham Teich. 1972. Genetics of white spruce. USDA Forest Service Research Paper, WO-15. 24 pp.

Stellrecht, J.W., C.A. Mohn, and William Cromell. 1974. Productivity of white spruce seed sources in Minnesota test planting. Minnesota Forestry Research Note No. 215. pp. 4.

Table 1. Origin and survival of 25 white spruce seed sources in five Minnesota tests, 15 years after planting.

Seed Source Nr.	Origin ^a			Percent Survival by Plantation ^b					
	State or Province	Latitude (°N)	Longitude (°W)	1 Gibbs Nelson	2 North Branch	3 Cloquet	4 Gunn Park	5 Burgeson's Landing	6 Combined
1657	Labrador	52.6	56.4	--	80	90	85	25	--
1658	Labrador	53.8	60.1	60	75	90	100	62	77
1659	New Bruns.	47.8	68.4	40	85	85	100	62	81
1655	Maine	44.8	68.6	55	90	80	98	50	81
1661	Quebec	48.3	71.4	70	100	95	100	50	81
1649	New Hamp.	44.8	71.4	65	90	85	95	00	80
1644	New York	44.4	74.1	--	85	90	98	62	--
1660	Quebec	46.5	76.5	60	70	90	100	88	90
1663	Ontario	45.7	76.8	65	80	75	100	75	83
1662	Ontario	48.0	81.0	70	80	100	98	88	89
1686	Ontario	52.2	81.7	50	75	85	88	62	76
1676	Michigan	44.5	83.8	80	70	85	100	100	88
1645	Wisconsin	45.7	89.1	70	75	90	100	62	85
1687	Ontario	48.5	89.5	65	50	90	100	62	80
1669	Minnesota	47.6	94.2	--	--	75	90	100	--
1647	Minnesota	47.6	94.2	95	60	90	100	50	85
3511	Minnesota	47.6	94.2	55	55	90	100	88	82
1631	Manitoba	49.8	99.5	60	65	90	98	38	79
1664	Manitoba	54.6	101.6	50	90	85	92	38	77
1628	So. Dakota	44.2	103.9	--	60	90	100	75	--
1665	Sask.	59.3	106.0	65	70	95	95	50	81
1630	Montana	46.8	109.5	--	--	--	95	--	--
1677	B. C.	54.0	123.0	55	85	80	90	50	78
1653	Alaska	63.8	144.9	--	--	80	95	25	--
1654	Alaska	66.6	145.2	20	--	--	98	--	--
Mean, all sources				60	76	87	96	61	83

^a Sources listed from east to west.

^b Percentages for Burgeson's Landing based on two replications (8 trees/source); for Gibbs Nelson, North Branch, Cloquet based on five replications (20 trees/source); and for Gunn Park based on ten replications (40 trees/source).

Table 2. Heights as a percent of plantation mean of 25 white spruce seed sources in five Minnesota tests, 15 years after planting.

Seed Source ^a	Plantation					Burgeson's Landing ^b
	1	2	3	4	5	
	Gibbs Nelson	North Branch	Cloquet	Gunn Park	1-4 Combined	
(Sources Common to Plantations 1 - 4)						
1663 (Ont.)	112*	131*	122*	129*	120*	130
1647 (MN)	109*	117*	103*	120*	110*	137
1660 (Que.)	116*	111*	107*	116	110*	121
1649 (NH)	103*	114*	124*	114	110*	--
1645 (WI)	111*	124*	91	115	109*	128
1662 (Ont.)	97*	108*	122*	112	109*	136
3511 (MN)	106*	106*	108*	115	106*	141
1659 (N.B.)	117*	99	117*	107	106*	109
1631 (Man.)	100*	125*	104*	106	106*	83
1655 (ME)	114*	118*	91	107	106*	122
1687 (Ont.)	103*	115*	117*	103	105	124
1676 (MI)	103*	115*	100*	104	103	107
1661 (Que.)	99*	108*	110*	105	102	131
1686 (Ont.)	101*	78	115*	90	92	112
1664 (Man.)	87	87	86	91	86	80
1658 (Lab.)	82	76	79	79	77	94
1665 (Sas.)	88	66	79	78	76	76
1677 (B.C.)	69	66	97	75	73	82
(Sources Not Planted in All Plantations)						
1644 (NY)	--	108*	103*	110	--	135
1669 (MN)	--	--	87	118	--	114
1628 (SD)	--	78	111*	91	--	88
1657 (Lab.)	--	54	61	65	--	76
1654 (AL)	72	--	--	49	--	--
1653 (AL)	--	--	53	55	--	62
1630 (MT)	--	--	--	41	--	--
Mean Height	4.39m 14.4ft	3.96m 12.9ft	3.02m 9.8ft	5.58m 18.1ft	4.37m 14.2ft	3.45m 11.5ft
Mean survival (%)	60	76	87	96	83	61
Coefficient of Variation (%)	13.3	19.0	16.7	10.0	9.1	--

^a Listed in order of source ranking in tests 1 - 4 combined.

^b Burgeson's Landing data not tested statistically.

* Does not differ statistically from tallest source in test, tallest source underlined.

Table 3. Diameters as a percent of plantation mean of 25 white spruce seed sources in four Minnesota tests, 15 years after planting.

Seed Source ^a	Plantation				
	1	2	3	4	1-4 Combined
	Gibbs Nelson	North Branch	Cloquet	Gunn Park	Combined
(Sources Common to Plantations 1 - 4)					
1663 (Ont.)	137*	142*	136*	152*	135*
1647 (MN)	107*	130*	118*	141*	119*
1655 (ME)	135*	128*	94	121	116*
1645 (WI)	119*	134*	96	129	116*
1660 (Que.)	137*	115*	100*	123	115*
1659 (N.B.)	131*	100*	121*	122	112*
1649 (NH)	110*	109*	141*	123	112*
3511 (MN)	122*	102*	104*	125	109
1676 (MI)	109*	125*	100*	115	107
1687 (Ont.)	100*	120*	123*	114	107
1661 (Que.)	100*	114*	110*	112	103
1631 (Man.)	88	130*	99	110	102
1662 (Ont.)	84	102*	129*	115	99
1686 (Ont.)	99	64	121*	92	86
1664 (Man.)	72	80	79	89	76
1658 (Lab.)	67	61	75	78	66
1677 (B.C.)	53	52	97	65	60
1665 (Sas.)	81	43	61	62	59
(Sources Not Planted in All Plantations)					
1644 (NY)	--	136*	109*	137	--
1628 (SD)	--	76	118*	84	--
1669 (MN)	--	--	66	128	--
1657 (Lab.)	--	38	58	47	--
1654 (AL)	60	--	--	34	--
1653 (AL)	--	--	--	36	--
1630 (MT)	--	--	--	37	--
Mean	6.7cm 2.6in	6.0cm 2.4in	3.5cm 1.4in	8.1cm 3.2in	6.4cm 2.5in
Coefficient of Variation (%)	21	30	27	15	15

^a Listed in order of ranking in tests 1 - 4 combined.

* Source does not differ statistically (.05 level) from source with the largest diameter in test, largest source underlined.

Table 4. Tree diameter² x height as a percent of plantation mean for 25 white spruce seed sources in four Minnesota tests, 15 years after planting.

Seed Source ^a	Plantation				
	1	2	3	4	1-4 Combined
	Gibbs Nelson	North Branch	Cloquet	Gunn Park	Combined
(Sources Common to Plantations 1 - 4)					
1663 (Ont.)	199*	225*	198*	233*	204*
1647 (MN)	105	160*	142*	191	148*
1660 (Que.)	174*	127*	93*	147	135
1645 (WI)	109	187*	77*	151	133
1655 (ME)	145*	160*	88*	136	130
1659 (N.B.)	139*	73	135*	133	112
1649 (NH)	101	93	199*	135	111
1676 (MI)	108	133*	77*	125	111
3511 (MN)	99	91*	98*	139	107
1661 (Que.)	88	133*	123*	110	102
1687 (Ont.)	99	123*	125*	107	101
1631 (Man.)	62	142*	90*	106	95
1662 (Ont.)	71	88	170*	121	95
1686 (Ont.)	82	45	193*	70	69
1664 (Man.)	50	51	38	66	53
1658 (Lab.)	32	24	41	45	34
1665 (Sas.)	55	15	28	29	30
1677 (B.C.)	26	21	101*	33	30
(Sources Not Planted in All Plantations)					
1644 (NY)	--	171*	115*	167	--
1628 (SD)	--	31	114	55	--
1669 (MN)	--	--	35	161	--
1657 (Lab.)	--	7	14	21	--
1654 (AL)	65	--	--	6	--
1653 (AL)	--	--	5	9	--
1630 (MT)	--	--	--	5	--
Plantation mean	.026m ³ .93ft ³	.023m ³ .84ft ³	.006m ³ .21ft ³	.050m ³ 1.80ft ³	.029m ³ 1.02ft ³
Coefficient of Variation (%)	44	72	81	35	40

^a Listed in order of source ranking in tests 1 - 4 combined.

* Does not differ statistically (.05 level) from largest source in test, largest source underlined.