

SURVIVAL AND HEIGHT GROWTH OF NORTHERN
WHITE-CEDAR FROM 18 PROVENANCES

Richard M. Jeffers^{1/}

Abstract.--Northern white-cedar from 18 provenances was evaluated for total height in the nursery and for survival and total height in two field plantings in northern Wisconsin and in western Upper Michigan. There were significant differences among provenances in survival at one location and in height at both field locations 5 years after planting; there were no differences among provenances in height in the nursery. Total height was moderately, but significantly correlated between the plantings. The data suggest that there is significant genetic variation and genotype-environment interaction in northern white-cedar, but these traits may not be expressed when trees are grown under optimum conditions.

Northern white-cedar occurs naturally on a wide variety of sites. It grows both in swamps and on moist, well drained, upland sites. Morphologically, the species is similar throughout its natural range, and growth of northern white-cedar from different provenances in the nursery and in some field plantings appears to be relatively uniform, suggesting little genetic variation in the species (Wright 1970). Wright (1976) also states that "even in low-mortality plantations that are growing well, it has not been possible to detect statistically significant differences in any trait." However, the existence of many ornamental cultivars (Dallimore and Jackson 1967) suggests genetic variation in the species, and localized wet lowland and adjacent dry upland ecotypes have been reported in Wisconsin (Habeck 1958, Musselman et al 1975).

To determine the geographic pattern of genetic variation in northern white-cedar a cooperative, rangewide provenance study (NC-99) was begun by the School of Forestry, University of Minnesota in 1964. Seed was collected from 32 stands located throughout the natural range of the species. Seed from various provenances was sown in nurseries in Michigan, Minnesota, and Wisconsin and resulting seedlings were field planted at several locations in the three Lake States and Illinois.

In this paper, survival and height growth of trees from 18 provenances field planted for 5 years in northern Wisconsin and western Upper Michigan are compared with similar data from 4-year-old nursery-grown trees.

^{1/} Plant Geneticist, USDA Forest Service, North Central Forest Experiment Station, Institute of Forest Genetics, Rhinelander, Wisconsin.

MATERIAL AND METHODS

Seed collected from 18 provenances (table 1) was stratified in moist peat moss (34-40°F) for 60 days before sowing in the Hugo Sauer State Nursery, Rhinelander, Wisconsin. Resulting seedlings were transplanted into 4 replications in the nursery at the end of the second growing season.

Seedlings (2-2) were lifted from the nursery and field planted in late April in northern Wisconsin near Lake Tomahawk, Oneida County (Lat. 45.8°N, Long. 89.6°W) and in early May in western Upper Michigan on the Ottawa National Forest near Marenisco, Gogebic County (Lat. 46.4°N, Long. 89.7°W). Trees were hand planted at a spacing of 8' x 8' in a randomized, complete block design with 4-tree linear plots. Ten blocks were established at Lake Tomahawk and 15 at Marenisco. Two border rows surround each planting. The planting site at Lake Tomahawk was strip treated with Amazine the summer before planting; the Marenisco planting was not treated with herbicide. Both plantings were fertilized with granular 10-10-10 shortly after planting in 1969 and again in 1971. The Marenisco planting was also treated with lime in 1969 and 1971 in an attempt to increase soil pH; soil tests indicated a pH of about 5.0. Both plantings have been mowed periodically since planting.

Total heights of 15 seedlings from each plot were determined at age 4 (2-2) in the nursery. Survival and total height of all trees in both field plantings were determined after 5 growing seasons (age 9 from seed) in the field. Differences among provenances in survival and total height at each location were determined by two-way analyses of variance. Relative total height of the provenances in the nursery and at both field locations was determined by simple correlation.

RESULTS

Nursery

Total height of trees at age 4 in the nursery averaged 37 cm. Variation in total height among provenances ranged from 31 cm for source 3349, Kane Co., Illinois to 43 cm for source 3270 from Forest Co., Wisconsin. However, there were no significant differences in total height among provenances or replications.

Field Plantings

Marenisco, Michigan.--Plantation survival was 89 percent. Variation in survival among provenances ranged from 68 percent for source 3348, Blanford Twp., Ontario to 100 percent for source 3347, Houghton Co., Michigan (table 1). There were significant differences in survival among provenances and replications.

Plantation mean height was 88 cm and variation among provenances ranged from 80 percent of the planting mean for source 3341, Bland Co., Virginia to 124 percent of the mean for source 3270, Forest Co., Wisconsin (table 1). Differences in height were significant among provenances and replications.

Table 1.--Survival and total height ^{1/} of northern
white cedar from 18 seed sources.

Source No.		Origin	Lat.	Marenisco		Lake Tomahawk	
IFG	UMN			Survival	Height	Survival	Height
			^o N	%	CM	%	CM
3270	22	Forest Co., Wis.	45.8	98	109	95	87
3344	29	Washburn Co., Wis.	46	88	105	90	109
3340	18	Itasca Co., Minn.	47	95	102	100	93
3271	23	Forest Co., Wis.	46.0	82	97	98	95
3351	36	Clinton Co., N.Y.	44.6	90	95	95	95
3343	28	Grand Isle Co., Vt.	44.6	82	93	98	104
3342	21	Shawano Co., Wis.	44.6	88	92	95	67
3345	30	Somerset Co., Me.	45.6	92	91	95	84
3346	31	Chippewa Co., Mich.	46.3	92	87	95	82
3352	38	Annapolis Co., N.S.	44.9	90	85	98	83
3347	32	Houghton Co., Mich.	47.1	100	85	95	80
3339	17	Orleans Co., Vt.	44.7	82	84	98	82
3353	40	Gurney Twp., Ont.	49.5	92	83	85	95
3338	16	St. Louis Co., Minn.	48.0	98	82	90	79
3350	35	Kenora Dist., Ont.	51.5	92	81	100	86
3348	33	Blanford Twp., Ont.	43.3	68	76	80	86
3349	34	Kane Co., Ill.	42	85	73	95	71
3341	19	Bland Co., Va.	37.1	92	70	100	78
			Mean	89.2	88.3	94.6	86.4
			S $\bar{x}$	2.27	5.07	1.86	6.06

^{1/} Age 9 (2-2-5)

Lake Tomahawk, Wisconsin.--Survival at the Lake Tomahawk site averaged 95 percent (table 1). There were no significant differences among provenances in survival and only 2 sources, 3348 and 3353 from Ontario had less than 90 percent survival.

Total height of all trees averaged 86 cm and variation among provenances ranged from 78 percent of the planting mean for source 3342, Shawano Co., Wisconsin to 127 percent of the mean for source 3344, Washburn Co., Wisconsin. Differences in height among sources and replications were significant.

DISCUSSION

Survival of most provenances was excellent and variation in this character appears to be random.

In general, provenances from intermediate latitudes ($44.6-47^{\circ}\text{N}$) grew best while those from the highest (51.5°N) and lowest ($37.1-43.3^{\circ}\text{N}$) were the slowest growers. The best seed sources were from Forest Co. (3270, 3271) and Washburn Co. (3344), Wisconsin; Itasca Co. (3340), Minnesota; Clinton Co. (3351), New York; and Grand Isle (3343), Vermont, while the poorest sources were from Kenora Dist. (3350) and Blanford Twp. (3348), Ontario; Kane Co. (3349), Illinois; and Bland Co. (3341), Virginia.

Although no significant differences among provenances in 4-year heights were found, correlation between total height in the nursery and at Marenisco was significant at the 1 percent level ($r = .75$). Correlation of height in the nursery and at Lake Tomahawk, However, was not as high and just barely missed reaching significance at the 5 percent level ($r = .46$). This lower correlation may have resulted from reduced growth of potentially faster growing trees resulting from severe deer browsing shortly after planting; the planting was fenced shortly thereafter. Trees from some provenances may have been more severely browsed than others causing a shifting of height rank in the plantings. Unfortunately, no evaluation of browse damage was made because most trees appeared to be severely damaged.

Height of trees in the 2 plantings was moderately correlated ($r = .56$, significant at 5 percent). The most notable changes in rank were sources 3342, Shawano Co., Wisconsin from 7 at Marenisco to 18 at Lake Tomahawk, 3353, Gurney Twp., Ontario from 13 at Marenisco to 5 at Lake Tomahawk; and 3348, Blanford Twp., Ontario from 16 at Marenisco to 9 at Lake Tomahawk. The changes in ranking in the two field tests and the change from no significant variation to significant variation between the nursery and field plantings suggest important genotype-environmental interactions in the responses of the provenances studied. Interpretation of these interactions, however, must await inclusion in the analysis of several additional sets of test data representing additional environments.

The data from these field tests suggest that genetic variation in height growth of northern white-cedar may be expressed when the species is grown under conditions similar to our field tests. However, when grown under

essentially competition-free conditions, such as in our nursery test and in 8-year-old tests conducted in Lower Michigan (Wright 1976), genetic variation in height growth of northern white-cedar may not be expressed. This interpretation of our results indicates the need for more research on the adaptive variation in this species.

In contrast to the opinion expressed by Wright (1970, 1976) that little genetic variation exists in this species, our results indicate considerable genetic variation, at least in terms of total height.

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