FOREST MANAGEMENT NOTE

Note 50 **Northwest Region**

SURVIVAL AND GROWTH OF JACK PINE PROVENANCES IN MANITOBA

A range-wide provenance test of jack pine (*Pinus banksiana* Lamb.) was planted in southeastern Manitoba in 1972. The test was planted by the Manitoba-Saskatchewan Region of the Canadian Forestry Service[1] as part of a cooperative study initiated by the Petawawa Forest Experiment Station (Petawawa National Forestry Institute) (Holst 1967). Objectives of the cooperative study were to assess the total variability of jack pine in relation to climate and site and to provide information to delineate seed zones. The virtual destruction of the Manitoba plantation by fire after the 10-year measurement has curtailed attainment of the study's objectives in this region. Results to the 10th year are presented along with information that could be acquired from the few trees surviving to the 15th year to assess the value of provenance introduction to southeastern Manitoba. Although these results can contribute only slightly to the cooperative study's main objective, practical use can be made of them in the context of the ongoing jack pine breeding program for southeastern Manitoba.

MATERIALS AND METHODS

Seed lots were collected for the study from 1954 to 1962 by many cooperators (Holst 1967). Samples from 78 seed lots were received for a test in the Manitoba-Saskatchewan Region in 1968. Another three lots (NFC1, NFC2, and NFC3) were formed for this experiment by mixing equal numbers of seeds from 8 to 13 trees selected in three locations in the region. Source distribution is shown in Figure 1. Lot 3283, originating about 50 km northeast of the plantation, was considered to be the local seed lot for comparison purposes.

The 81 seed lots were reared in nursery seedbeds near Winnipeg, Manitoba, in a randomized block layout with two replications. The 3-0 seedlings were lifted in April 1972 and stored at 0-4°C for 3 weeks until they were planted.

The planting site was in southeastern Manitoba at 49°13'N, 96°20'W, at an elevation of 328 m, with an orthic eutric brunisol (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978) developed on rapidly drained calcareous stratified sand and gravel deposits (Smith and Ehrlich 1964). Scattered jack pine trees were removed from the site, and finned barrels were drawn across the site to form furrows at 1.8-m spacing in the summer of 1971. Five replications were laid out in lattice square design. In each replication the nine columns required by the design lie in nine adjacent furrows, with the design's nine rows and four-tree row plots

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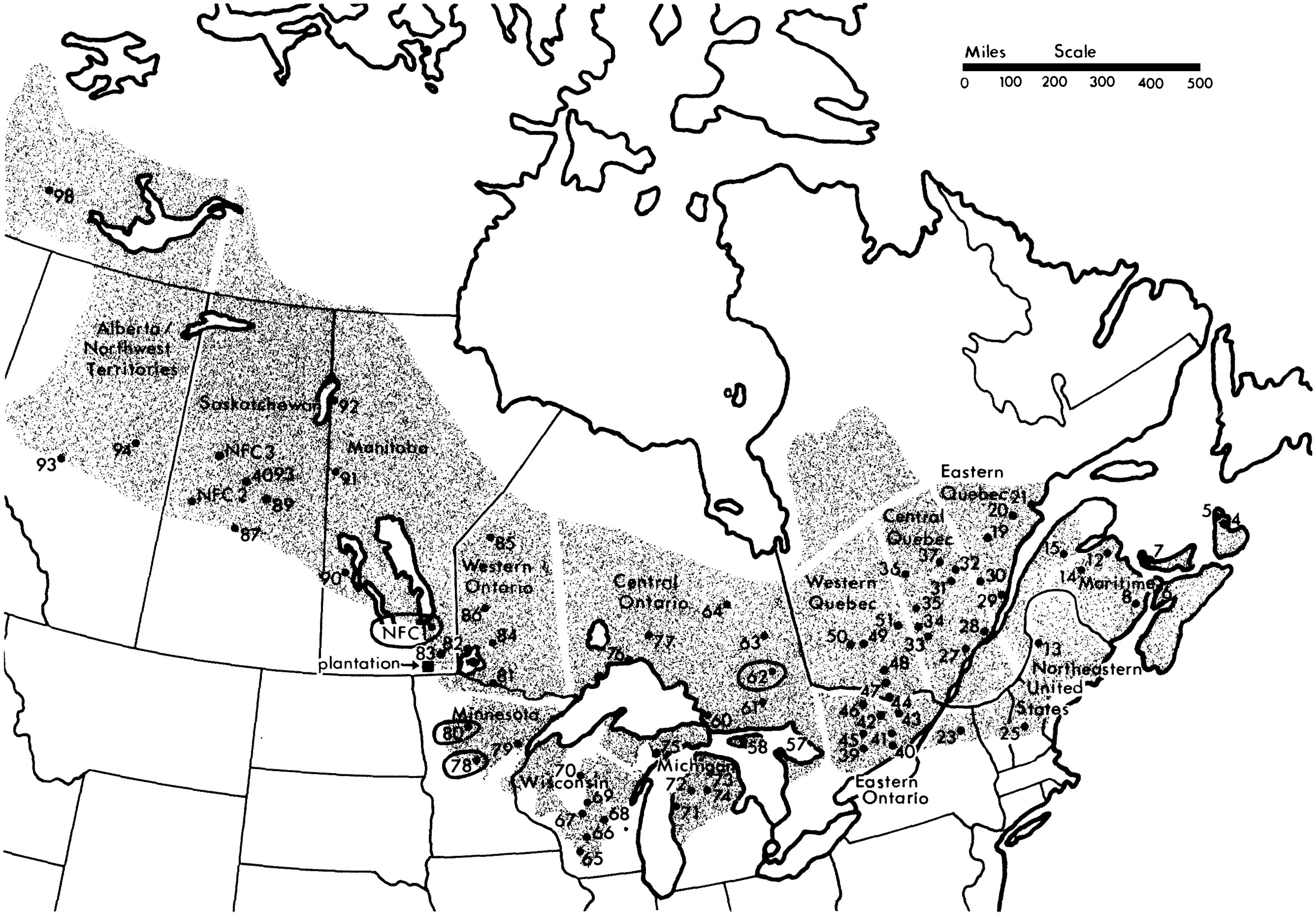

Figure 1. Provenances, source areas, and plantation location for the jack pine provenance test in Manitoba. Two-digit lot numbers are Petawawa numbers (Holst 1967), with the common leading "32" omitted. Circled sources exceeded the local provenance in mean height at 10 years.

occupying 36 planting positions at 1.8-m spacing along each furrow. Some planting positions were left unfilled because of stock shortages, which were not recorded. A two-row border of jack pine surrounds the plantation.

Survival was recorded 1 year after planting. Stocking at this examination was used as the denominator for calculating survival at 10 years after planting. The number of living seedlings for each provenance ranged from 11 to 20 at this first examination.

Height, diameter outside bark, and a stem quality rating were recorded 10 and 15 growing seasons after planting. Diameter was measured at 1.0 m above ground at 10 years and at 1.3 m at 15 years. Stem quality was subjectively rated on a scale of 1 (best) to 5 (worst), based on frequency and severity of crooks and success in regaining apical dominance after leader damage. Trees that were not over 1 m in height at 10 years were generally severely damaged rather than slow-growing and were excluded from analysis of growth and stem quality.

Lattice square analysis of variance was performed on the 10-year data according to the procedure of Cochran and Cox (1957) using a FORTRAN program run on the Northern Forestry Centre VAX 8350. Estimated values were first constructed for plots with no valid trees (Cochran and Cox 1957). Multiple regression was performed for provenance mean height adjusted for row and column effects on source parameters using Lotus 1-2-3[2].

Provenances were grouped subjectively into 14 source areas to simplify description of variation patterns.

Growth variation among source areas from 10 to 15 years was assessed in terms of volume. An index of volume at 10 and 15 years was calculated for each surviving tree as $(\text{diameter}/2)^2 \times \text{height}$, and growth was calculated as the difference. One-way analysis of variance was performed on the volume index growth values for individual trees grouped by source areas. Effects of the fire on growth of the surviving trees were considered as random environmental variation. All of the calculations for trees surviving to 15 years were carried out using SAS procedures (SAS Institute, Inc. 1985).

RESULTS

Survival, adjusted height, and adjusted stem quality at 10 years from planting are shown for source areas in Table 1. Out of 1620 planting positions, 1375 (85%) were stocked with a living tree after 1 year, and 1289 (94%) of these living trees survived to 10 years. Sixty-eight surviving trees were shorter than 101 cm at 10 years, and 42 of these were from the northeastern USA, Maritimes, Michigan, and Saskatchewan source areas. Survival rates lower than 90% occurred in 14 of the 81 provenances and 2 of the 14 source areas (eastern Quebec and Michigan). Thirty-five provenances had no mortality between 1 and 10 years after planting.

Plantation means at 10 years were 234 cm for height and 3.21 for stem quality. Provenance variation was significant for both traits. Four provenances were taller than the local one, with a maximum superiority of 10 cm (3%). Source areas for these tallest provenances were Minnesota (two provenances), Manitoba, and central Ontario.

Regression analysis revealed significant contributions of provenance latitude and longitude to mean height. Adding the squares of latitude and longitude as independent variables increased the proportion of variation explained by regression from 0.15 to 0.46. The negative coefficients of the squares of latitude and longitude suggest that intermediate values are most favorable. Source elevation did not contribute significantly to growth variation among provenances.

Height means for source areas corroborated the evidence from regression analysis. The poorest growth was from source areas furthest east, south, and northwest of the plantation (northeastern USA, Maritimes, eastern Quebec, eastern Ontario, Michigan, Saskatchewan, and Alberta and Northwest Territories). The best source areas, other than Manitoba, were slightly south of the plantation (Minnesota, western and central Ontario, western and

[2] The exclusion of certain manufactured products does not necessarily imply disapproval, nor does the mention of other products necessarily imply endorsement by Forestry Canada.

Table 1. Survival, height, and stem quality of jack pine provenances at 10 years from planting, and volume growth from year 10 to year 15

Source area	Number of provenances	Survival (%)	Height		Stem quality		Volume growth	
			Mean (cm)	Range (% local)	Mean	Range	cm^3	No. trees
N.E. USA	4	91	182	48–74	4.0	3.3–4.6	1979	1
Maritimes	7	95	193	44–77	3.5	3.0–4.2	1804	6
E. Quebec	6	89	218	72–82	3.0	2.5–3.4	2557	8
Cent. Quebec	9	97	242	74–93	2.9	2.5–3.5	2914	27
W. Quebec	7	97	247	80–91	3.0	2.6–3.4	2991	20
E. Ontario	7	96	209	56–89	3.8	3.1–4.3	2657	25
Cent. Ontario	9	94	248	82–100	3.1	2.4–4.1	2540	22
W. Ontario	5	93	258	83–98	3.3	3.0–3.6	3066	16
Michigan	5	89	208	56–86	3.8	3.2–4.6	2562	7
Wisconsin	6	94	234	63–91	3.2	2.6–4.1	2836	22
Minnesota	3	96	287	94–103	2.7	2.4–2.9	4862	19
Manitoba	4	100	254	67–101	3.1	2.8–3.9	2913	15
Saskatchewan	6	97	219	56–90	2.9	2.7–3.4	2180	16
Alberta/N.W.T.	3	96	185	54–75	3.3	3.1–3.6	1278	7
Local		100	287		2.9		3196	4

central Quebec). The Wisconsin source area fell between these groups. Stem quality and survival means for source areas were in general agreement with the height results. Areas with above-average height were not below average in survival or stem quality.

The limited information that could be extracted from the 211 trees still alive at 15 years did not indicate any important changes (Table 1). Volume growth varied significantly among source areas. The Minnesota source area was still best, followed by a group consisting of central and western Quebec, western Ontario, Wisconsin, and Manitoba. The trees with the poorest growth were from source areas at the eastern (Maritimes, one tree from Maine) and northwestern (Alberta and Northwest Territories, and Saskatchewan) ends of the species range.

DISCUSSION AND CONCLUSIONS

Four nonlocal provenances surpassed the local provenance in mean height at 10 years and had a good survival rate. Two of these provenances were from the Minnesota source area, which had the best mean height at 10 years and the best volume growth from year 10 to year 15. It is likely that seed from the best Minnesota provenances would outgrow the seedlot designated as local for this plantation and that other Minnesota provenances could be found that would survive and grow well in southeastern Manitoba. Of the other two tallest provenances, one was from within 100 km of the plantation and the other was from central Ontario, located between other tested provenances having unexceptional mean height.

Growth that is superior to that of the local provenance in this plantation is not a sufficient criterion for a truly useful introduction. Results from an open-pollinated family test of eastern Manitoba wild parent trees indicated that the local provenance (at 49°30′N, 95°45′W) and the tallest Manitoba provenance (NFC1, at 50°32′N, 96°29′W) are inferior in volume growth at 10 years to other areas in southeastern Manitoba directly north of the plantation, around 49°20′N and 49°35′N (Klein 1983). A direct comparison is not possible between the best provenances in the provenance test and the best source stands in the family test. It would be reasonable to conclude that the best provenances would perform well in a new test designed for such a comparison. There is no assurance that they would prove to be advantageous introductions for direct use in the wild, unimproved state.

Nonlocal provenances that perform similarly to trees of local origin are likely to be genetically different from them. Incorporating the best provenances into the southeastern Manitoba improved breeding population is thus likely to increase the genetic diversity within the breeding population with little or no reduction in average growth capability. Increased diversity is expected to increase effectiveness of the breeding program in later generations. A convenient way to incorporate these provenances would be to carry out controlled matings between the best individual trees of the best provenances in the test plantation. The Minnesota provenance with the best mean height at 10 years had 15 survivors at 15 years (including some of the largest trees in the plantation), whereas the best Ontario provenance had only 4 survivors. Planting and assessing fresh seed lots from the original populations of the best provenances could be an alternative way to use the provenance test results in the breeding program.

Apart from protection of trees to be used for controlled mating, no further use is planned for this provenance test plantation.

J.I. Klein
November 1990

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