forest management note

Note No. 18 Northern Forest Research Centre Edmonton, Alberta

GENETICALLY IMPROVED JACK PINE FOR MANITOBA AND SASKATCHEWAN

Jack pine (*Pinus banksiana* Lamb.) is one of the major reforestation species in Manitoba and Saskatchewan. In 1967 the Canadian Forestry Service initiated a program for the genetic improvement of jack pine, with the purpose of increasing the growth rate and merchantable yields from commercial plantations by improving the genetic quality of planting stock. The first genetically improved materials, in the form of grafts for seed orchard establishment, were provided to provincial and industrial cooperators in 1979 and 1980. This note describes the program's strategy and progress; a detailed report is available on request (Klein 1982).

Breeding Districts

An improved population of jack pine is being developed for each of three geographically distinct areas: southeastern Manitoba, the uplands along the Manitoba-Saskatchewan boundary, and the southern portion of the forest zone in Saskatchewan, termed the eastern, central, and western breeding districts (Fig. 1). Program strategy is the same for all breeding districts, but each district has its own source materials and family-test plantations, which should ensure successful field performance of the improved planting stock in each of the three areas.

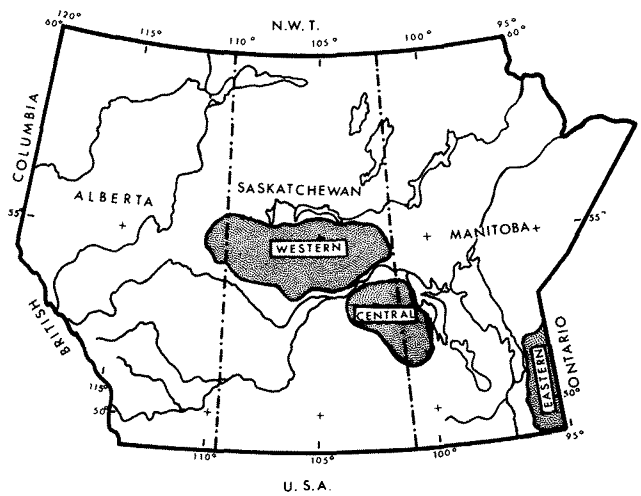

Figure 1. Location of eastern, central, and western breeding districts for the jack pine breeding program.

Program Strategy—First Generation

The breeding program's strategy for the first generation is illustrated for the eastern breeding district (Fig. 2); the western and central breeding districts are 2 and 4 years behind, respectively. Identification of genetically superior trees is based on analysis of performance observations in the *family-test* plantations. The *clone bank* is a plantation of grafts of all of the test families. Propagation materials obtained from only the genetically superior grafts in the clone bank are used to produce trees for *seed orchards*, where seed for improved planting stock will be mass-produced.

Arrows in the diagram indicate transfer and propagation of plant material (e.g., natural stands to family test and clone bank), derivation and use of information (family test to clone bank), or continuation of plantations (box to box directly below). The functioning and interrelationships of the family tests, the clone bank, and seed orchards in this program are briefly described below.

Family Tests

Family testing uses the known genetic correlation among related individuals to compute a reliable assessment

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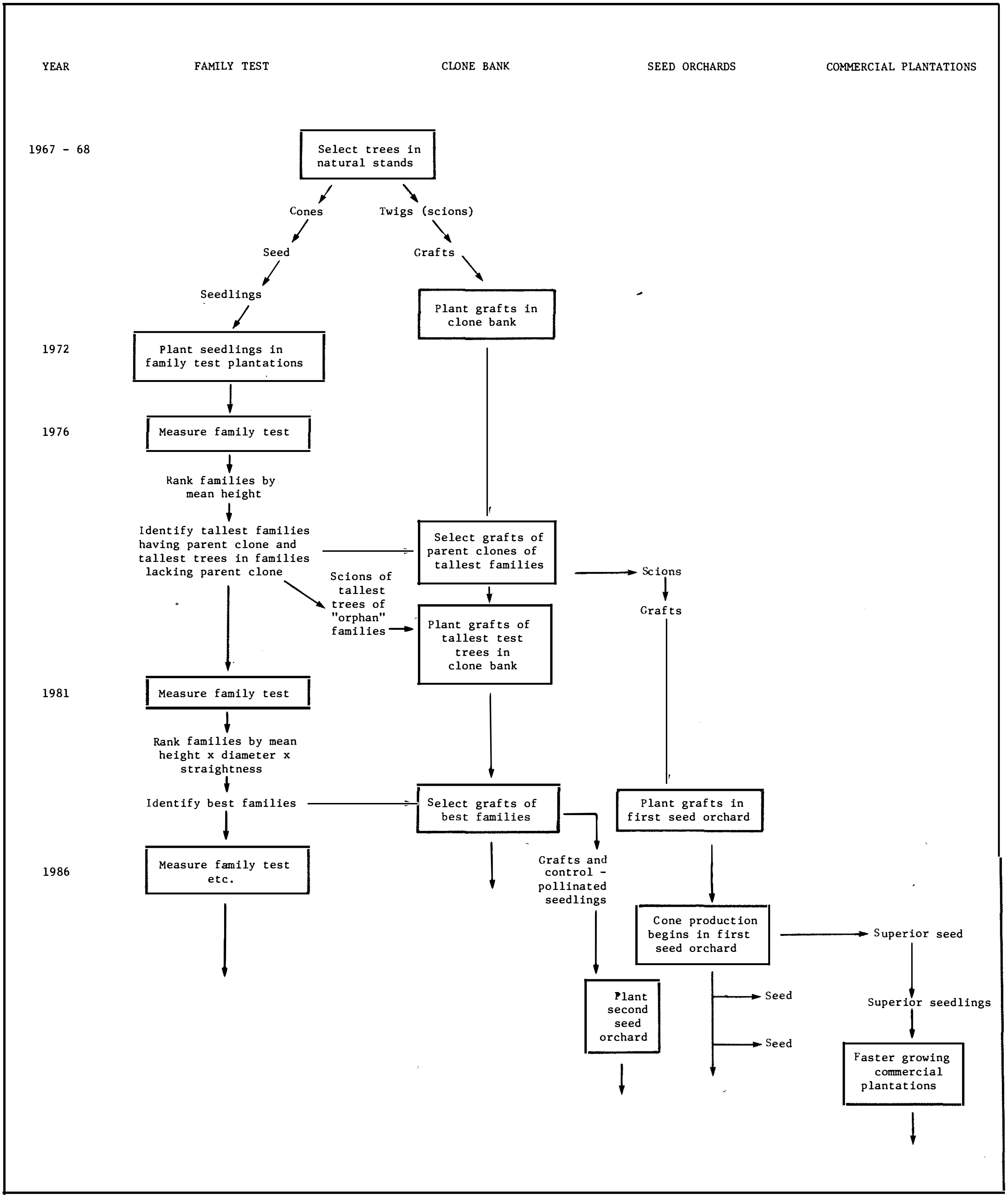

Figure 2. Breeding program strategy for the first generation for the eastern breeding district in southeastern Manitoba.

of the genetic quality of a large number of trees. The best of the assessed trees can then be identified, and their degree of genetic superiority can be estimated in quantitative terms. In this program, one family test consists of three or four replicated test plantations on representative jack pine planting sites in the test's breeding district. Each replicate consists of the same set of more than 200 open-pollinated progenies and one or two populations from bulked seed lots (controls) originating within the breeding district.

Each progeny in a test was reared from seed obtained from one tree in a natural stand. Straight, healthy, dominant or codominant trees were selected as seed parents. The mean performance of a progeny's trees over all replicates and plantations of the test in relation to the test's grand mean provides information on the genetic quality of that progeny's seed parent and on the genetic quality of every tree in that progeny. Nearly all progenies in each test originated within that test's breeding district. The numbers involved in the family tests are summarized in Table 1.

Test plantation trees may be measured or rated for any performance trait believed to be sufficiently correlated with desired performance and sufficiently variable genetically to justify the cost of observation. In this program, increases in growth rate and merchantable yield from commercial plantations are desired. Traits of interest thus include height; diameter; taper; size, angle, and number of branches; wood density; and resistance to pests. Each time a family test is measured, a judgment of which traits will be observed is required. For most traits the correlation with yield increases as family-test age increases, but observations are made on young family tests because some genetic improvement can be achieved from assessments that are only partly accurate. At 5 years from planting, only height was measured in all of the tests. The 10-year measurement of the eastern breeding district family test (Fig. 3) included height, diameter at 1 m (owing to the small size of the trees), and a subjective rating of bole crookedness.

Whenever there is more than one variable trait among progenies, any of the varying traits may be used in a multi-trait index to provide a single score for each progeny at each measurement. Progenies that rank near the top in a test are identified as being genetically superior. The ratio of a superior progeny's score to the test's grand mean score indicates the degree of superiority of average trees of that progeny.

Figure 3. Measurement of the jack pine family test in the eastern breeding district 10 years after planting.

Clone Bank

The clone bank functions as an intermediate step between the family-test plantations, where genetically superior trees are identified, and the seed orchards, where improved seed will be produced in quantity. The clone bank is a plantation of grafts of every family included in a family test. Most families have grafts of their naturally grown seed parent in the clone bank (parent clones), but where none of these survived, grafts of several of the family's tallest family-test trees at 5 years from planting were or will be substituted (progeny grafts).

Clone bank grafts are selected if their family's progeny score is superior, because each family's grafts are known to be genetically correlated with its family-test trees. Seed orchard trees will be produced from the selected clone bank grafts and will be genetically equivalent to those

Table 1. Details of the three jack pine family tests

Breeding district	Progenies	Controls	Plantations	Total replicates	Year planted
Eastern	209 + 6 from the western breeding district	1	4	15	1972
Central	214	2	3	9	1976
Western	214	2	4	12	1974

grafts (Fig. 2). Clone bank grafts are tended to promote production of propagation materials in quantities sufficient for seed orchard establishment on an appropriate scale. In October 1981 there were 2016 healthy grafts of 571 families in the clone bank, which will contain 3185 grafts of 637 families when it is filled.

Seed Orchards

Seed orchard trees will be produced by grafting scions from the selected clone bank grafts or by controlled pollination between grafts of different selected families. The propagation mode will depend upon grafting success, conelet production, and pollen production of selected clone bank grafts and will not influence the average genetic quality of the trees that are produced. These trees will be provided to cooperators, who will plant, own, and manage the seed orchards. Seed orchard trees may be produced after any periodic measurement of a family test, depending upon the results from analysis of the data and the need for additional seed orchard area.

Several hundred grafts were provided to cooperators in 1979 and 1980 for planting of seed orchards. Clone bank grafts were selected to provide scions based on superior progeny mean height at 5 years from planting in the eastern and western breeding district family tests. At that time, scions were not available from families lacking a parent clone or having only weak grafts of the parent clone. Some families with superior progeny mean height were thus excluded from selection. Eighteen to 25 selected parent clones from each of these two breeding districts had progeny mean heights averaging 7-8% above the grand means of their respective family tests. Because these progeny means were influenced by uncontrolled pollen sources believed to differ little in average genetic quality from their source breeding population average, the selected parent clones are believed to be 10-15% superior in height at 5 years. The correlation between height at 5 years and merchantable yield at maturity will become evident in successive periodic measurements.

Planting of seed orchards with the grafts provided to cooperators could be delayed until family-test results at 10 years from planting are available. Grafts of families that are not superior according to the 10-year results can then be discarded before the seed orchards are planted. The 5-year results will thus be used only to support the costs of graft production in order to expedite by a few years the application of the 10-year results.

During the remaining time before the 10-year results are in hand, additional seed orchard grafts will be produced for families that are superior at 5 years. Additional grafts will be produced of clones previously grafted in order to obtain an equal and sufficient number of grafts of each selected clone. Grafts will be produced for superior central district families and for superior eastern and western district families that were excluded from selection in 1980 because of their lack of clone bank grafts. Nearly all of the 209 eastern district families now have parent or progeny grafts of useful size in the clone bank, whereas fewer than 100 families were available in 1980.

Initiation of seed production from the family-tested seed orchards is still several years away, but seed will be available for eastern Manitoba by the fall of 1983 from a different kind of seed orchard. A plantation established in 1972 near Oakbank, Manitoba, was thinned in 1977 and 1981 to leave the best tree out of 20 planted on each 3.0 × 3.6 m plot. The 20 trees planted on each plot were from 20 eastern district progenies originating in one source area. Adjacent plots had progenies from different source areas. It is believed that the close initial spacing and the genetic diversity on each plot ensure the genetic superiority of the trees left after the 1981 thinning.

Recurrent Selection

Genetic improvement beyond selection and propagation of the genetically best trees in the existing family tests and clone bank will be pursued by recurrent selection. Second-generation populations will be produced by controlled pollination among the best clone bank and family-test trees. The *average* genetic quality of the second-generation populations will equal that of the best trees of the first-generation populations. The genetically best trees in the second-generation populations will be superior to any trees of the first-generation populations. Production of second-generation populations may begin for each breeding district about 10-25 years after the family-test plantations were established.

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REFERENCE

Klein, J.I. 1982. Establishment and first results of a jack pine breeding program for Manitoba and Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-247.

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