POPLARS CAN BE BRED TO ORDER FOR MINI-ROTATION FIBER, TIMBER AND VENEER PRODUCTION AND FOR AMENITY PLANTINGS

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Since 1950 there has been a boom in forest tree improvement effort but, as I have emphasized in a number of publications, genetic improvement of most forest tree species has been directed primarily toward selection and breeding within the species. For forest trees as for agricultural crops (Harlan, 1966) it is the Genus that through interspecific hybridization can provide the wide diversity of genotypes needed for maximum genetic improvement.

GENETIC IMPROVEMENT OBJECTIVES

Improvement objectives can be briefly listed as:

1. Environmental adaptability;
2. Rapid growth;
3. Disease and insect resistance;
4. Growth habit for specific uses including fiber, timber, and amenity plantings;
5. Wood and fiber quality for lumber, veneer, and reconstituted wood and fiber products.

Environmental Adaptability - Because of the extremely wide diversity of the available genetic resources, it will be possible to create poplar hybrids for use throughout and far beyond the geographic range and site requirements of the natural species.

Growth Rate - The rapid growth of selected individuals of native species of poplar, and particularly of species hybrids, has been reported in literally hundreds of technical and popular articles.

Disease and Insect Resistance - Poplars are susceptible to many diseases and insects but there is evidence that there are individual genotypes with field resistance to practically all of the so-far identified pests.

Growth Habit - Poplars vary widely in growth habit and timber form. These characteristics can be maintained through clonal propagation.

Wood and Fiber Qualities - Many of these qualities have been reported to be under sufficient genetic control to be maintained through clonal propagation.

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FACTORS THAT INFLUENCE GENETIC IMPROVEMENT

Factors related to rapid and successful breeding for multiple-trait improvement of forest trees, aside from sufficient and continuing funds, are:

1. The diversity of available genetic resources (germ plasm);
2. Productivity of controlled breeding methods;
3. Species crossabilities;
4. Feasibility of clonal propagation;
5. Age and periodicity of flowering;
6. Length of progeny test periods.

On the basis of these factors the genus *Populus* offers far greater possibilities for genetic improvement than any other genus of forest trees.

Diversity of Available Genetic Resources - The following five SECTIONS are recognized in the taxonomic classification of *Populus*, with a total of at least 25 *valid species* and literally hundreds of local races, natural hybrids, hybrid swarms, and introgressive populations.

Section Leuce--at least 6 species.
(White Poplars and Aspens)

Section Tacamahaca--at least 12 species.
(Balsam Poplars)

Section Aigeiros--at least 3 species.
(Black Poplars and Cottonwoods)

Section Leuciodes--at least 3 species.

Section Turanga--1 species (P. *euphratica* with many varients that may be varieties or races).

Poplars are limited to the northern hemisphere where they girdle the globe and extend from the northern tree line to a reported outlier of P. *euphratica* in Kenya at one degree above the equator. Although there are no native poplars below the equator, successful poplar culture, particularly with hybrids, has been introduced in the southern hemisphere.

The availability of germ plasm adapted to such an extremely wide diversity of climates, sites, and environments is apparent from the maps showing the world-wide range of poplar species (figures 1-4).[2]

Figures 1-4 are from "Poplars in forestry and land use," FAO Forestry and Forest Products Studies, No. 12, Rome, 1958.

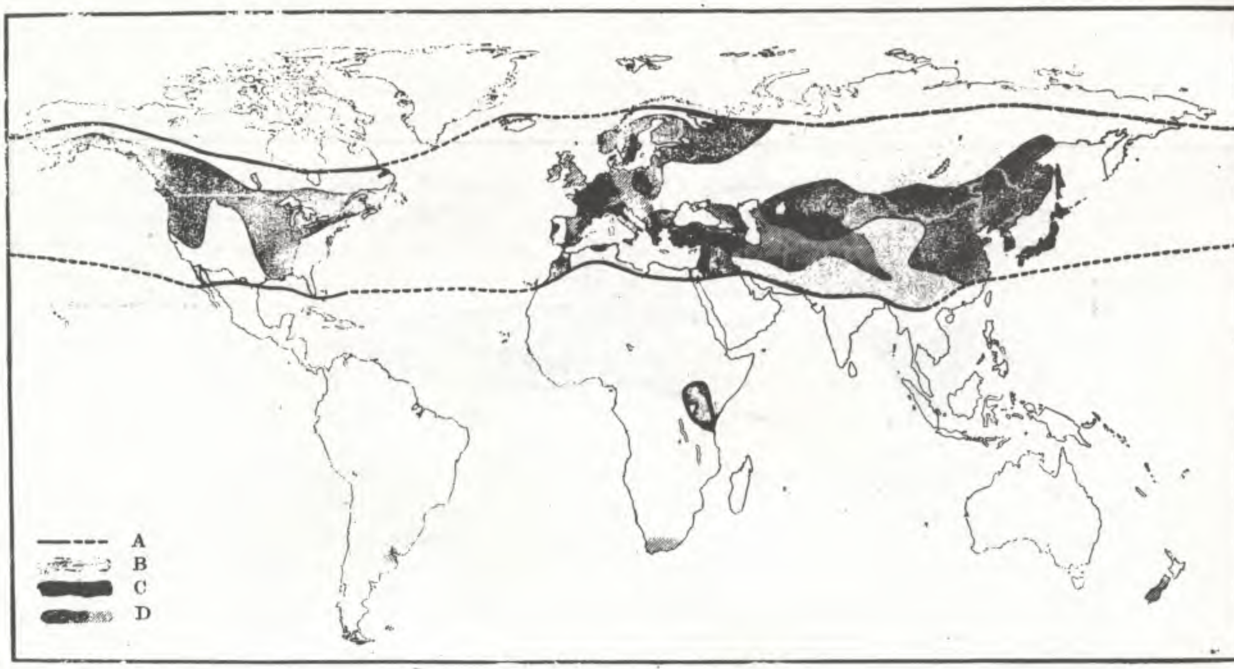

FIGURE 1. - World distribution of poplars.

A - Limits of the natural distribution area of the genus *Populus*.
B - Natural distribution of the genus *Populus*.
C - Zones where poplars are of particular importance.
D - Principal areas of poplar cultivation (little is known of their importance in eastern Europe and central Asia).

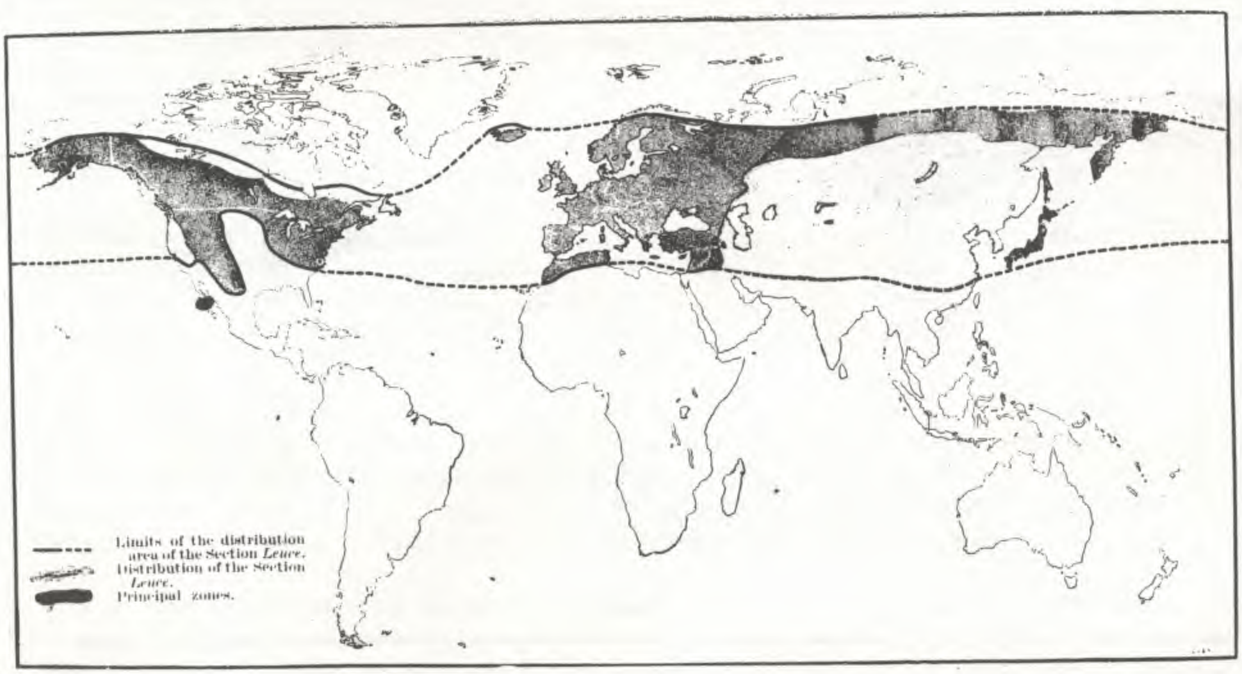

Figure 2.--World distribution Section LEUCE

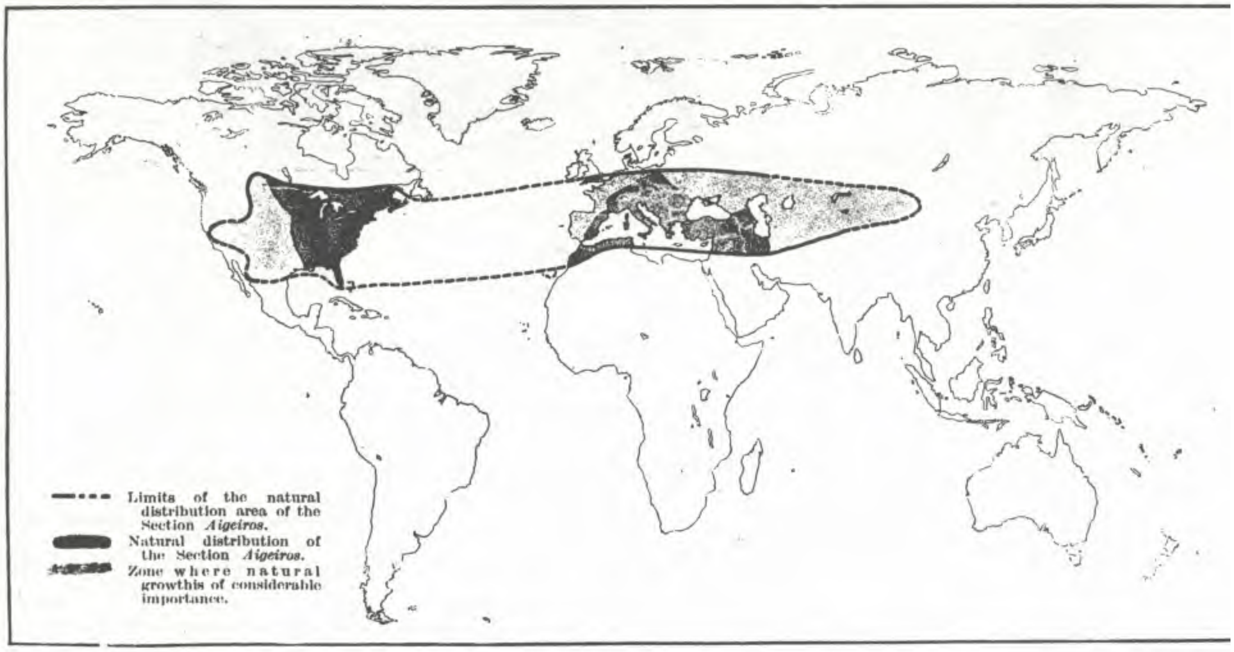

Figure 3.--World distribution of Section AIGEIROS.

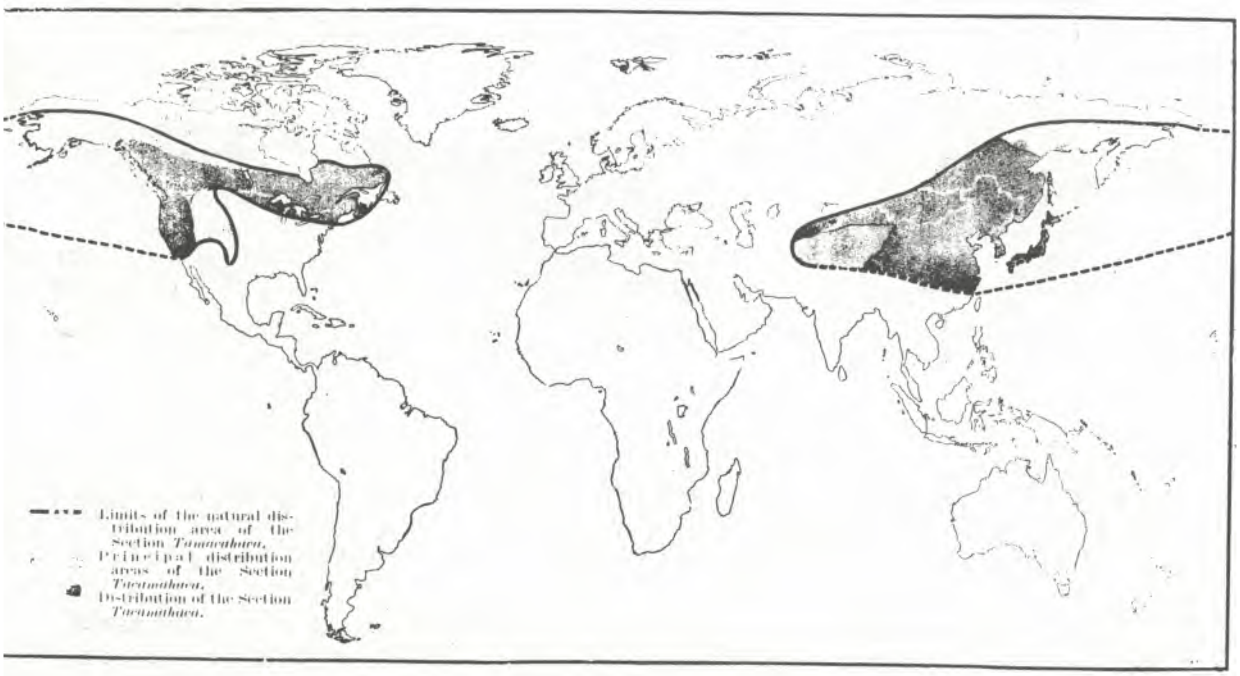

Figure 4.--World distribution of Section TACAMAHACA.

It is perhaps even more apparent from the extensive and overlapping ranges of our American species (figures 5-12).[3]

Within this broad geographic range, poplar species and varieties are adapted to a wide diversity of sites and soils. There is at least one species adapted to swamps, Populus heterophylla. And at least two are adapted to arid climates, Populus fremontii and Populus euphratica; the later species can also tolerate a high degree of salinity. Poplar species, varieties, and hybrids are growing on a wide range of soils from fertile bottomlands to infertile upland soils, and on soils ranging from pH 3.5 to pH 8.

A super-abundance of genetic resources are available for species and varietal hybridization of poplars; but there is urgent need for the exploration, conservation, and utilization of these world-wide resources. I have expressed the following opinions on the procedure for such research and its application in a paper published in Unasylva (Schreiner, 1968).[4]

Establishment of gene pools for future breeding should be with the objective of providing the broadest possible genetic base, on the sound assumption that many of the future needs for genetic improvement are not known at present. This requires the conservation of both presently identifiable and cryptic variation. I would predict that resistance to currently unimportant or unknown diseases, insects, and nematodes will be among the most sought-for cryptic characteristics in gene pools of forest trees.

There is need for clear distinction between sampling for variability and sampling for superiority--to collect and preserve the fullest possible genetic diversity rather than limit collection to preconceived ideas of superior trees.

It is impossible to predict for what particular characteristics and breeding methods forest-tree gene pools will be used; but it is certain that maximum utilization will require maximization of genetic diversity. For maximum future usefulness, forest-tree gene pools should provide for association of the widest possible diversity of genotypes in plantations designed to permit extensive recombination of genes through free pollination, or if necessary, artificial open-pollination.

[3]Figures 5, 6, 8-12 are from "Silvics of forest trees of the United States," Agriculture Handbook No. 271. U.S.D.A. Forest Service', Washington, DC. 1965. Figure 7 is from Schreiner, 1970, Genetics of eastern cottonwood. USDA Forest Serv. Res. Pap. W0-11, 24 p.

[4]The title of the paper as submitted for publication was "Remarks on Exploration, Conservation, and Utilization of the Gene Resources of Forest Trees." The editor of Unasylva changed the title to "Forest Tree Breeding" without consulting the author. Comments on the title from colleagues in several countries indicate that it has not received proper subject indexing.

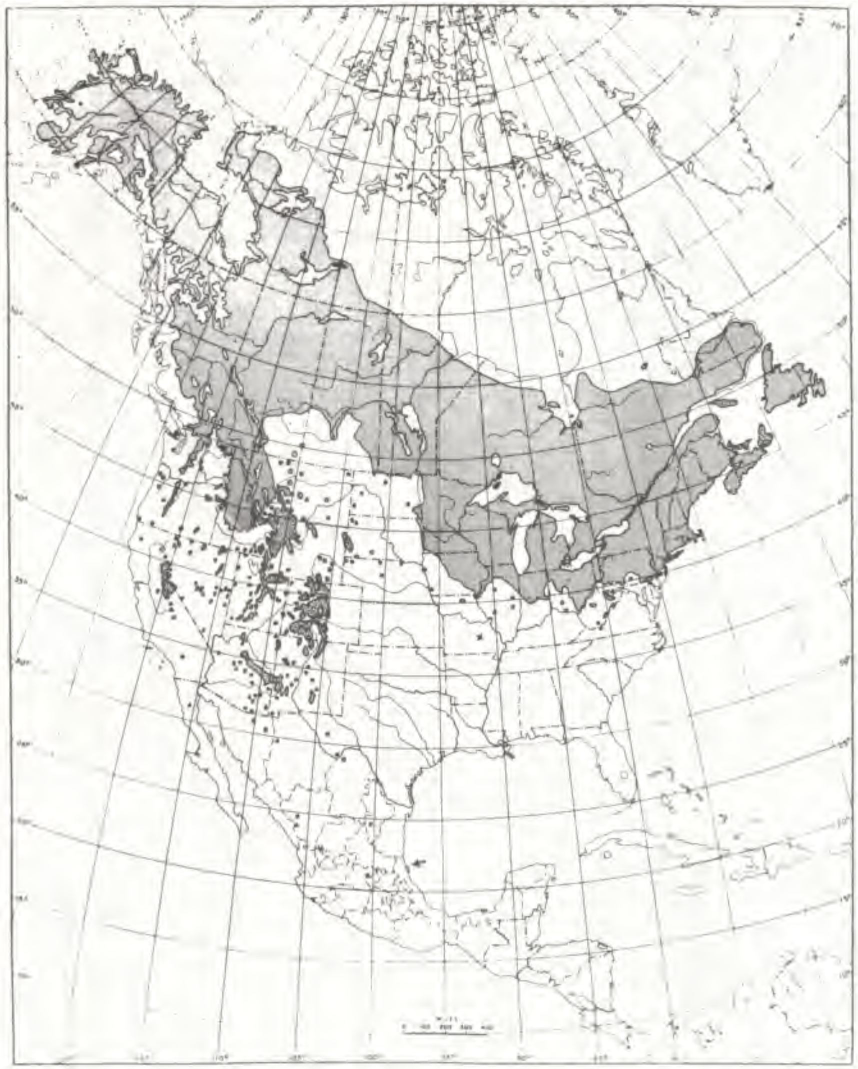

Figure 5.--The natural range of Populus tremuloides Michx.

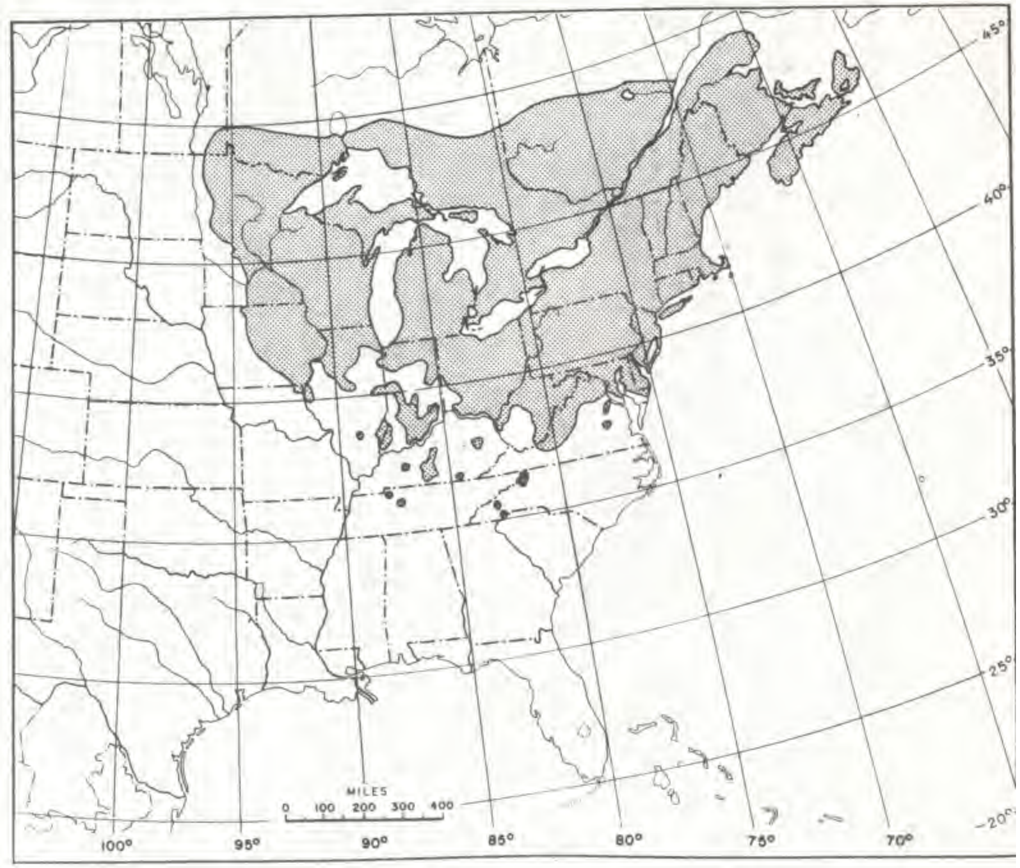

Figure 6.--The natural range of Populus grandidentata Michx.

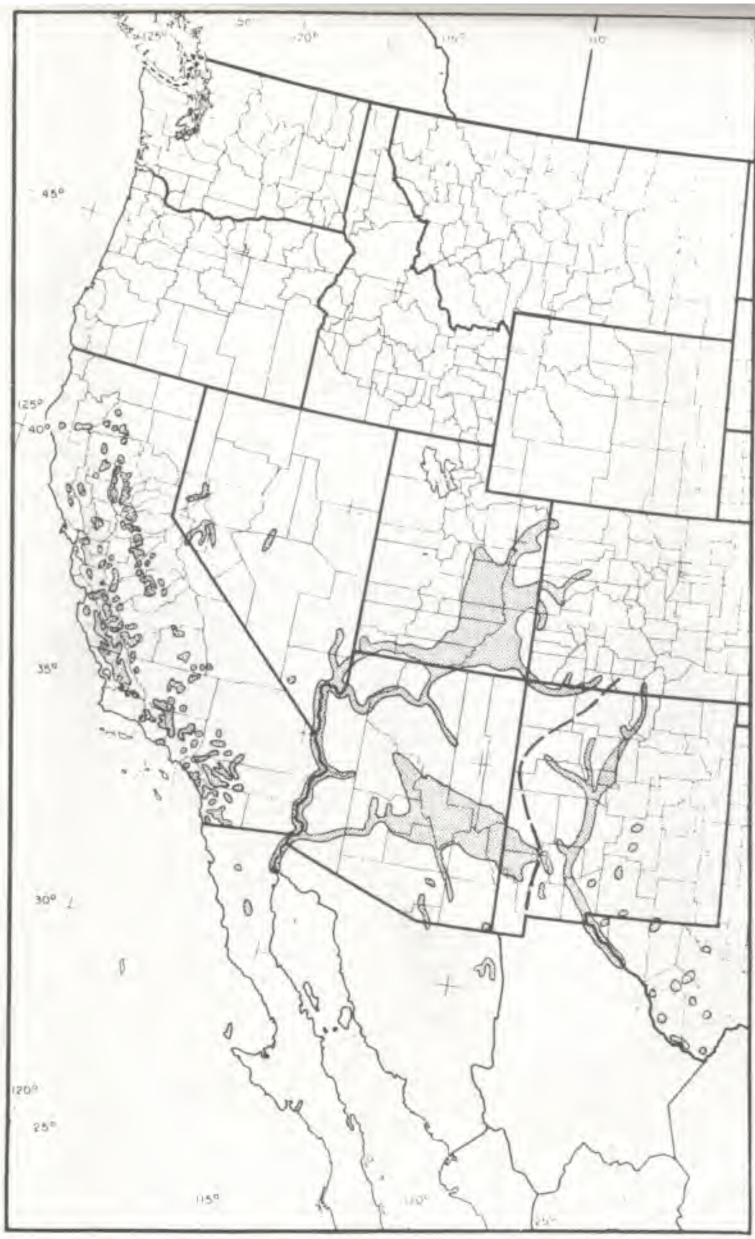

Figure 8.--The natural range of <u>Populus fremontii</u> S. Wats. Broken line separates var. <u>fremontii</u> (west) and var. <u>wislizeni</u> S. Wats. (east).

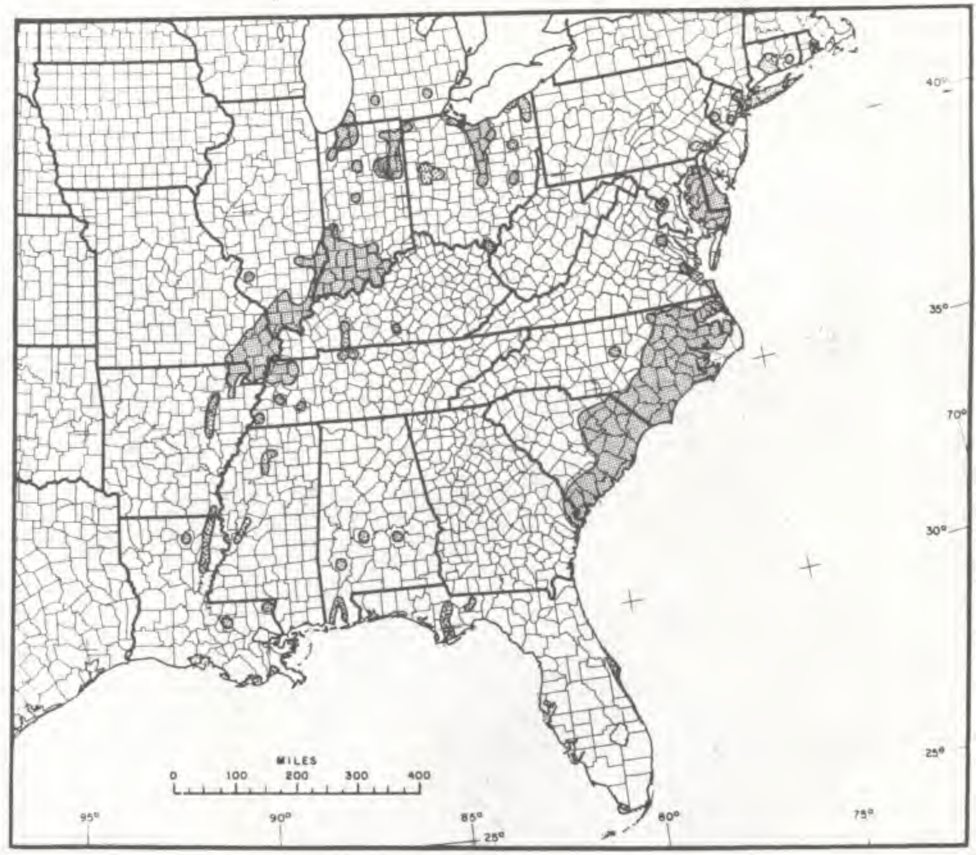

Figure 7.--The natural range of <u>Populus heterophylla</u> L.

Figure 9.--The natural range of Populus deltoides Bartr. var. ~~deltoides.~~

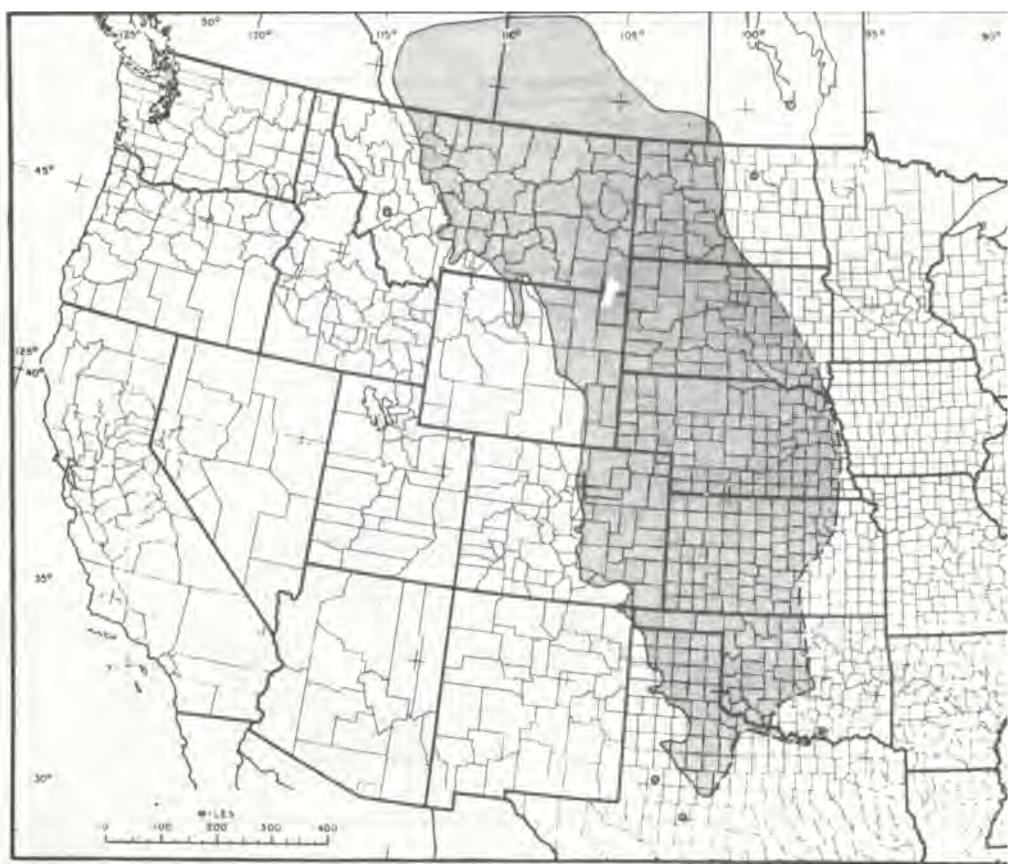

Figure 10.--The natural range of Populus deltoides var. occidentalis Rydb.

Figure 12.--The natural range of Populus trichocarpa Hook.

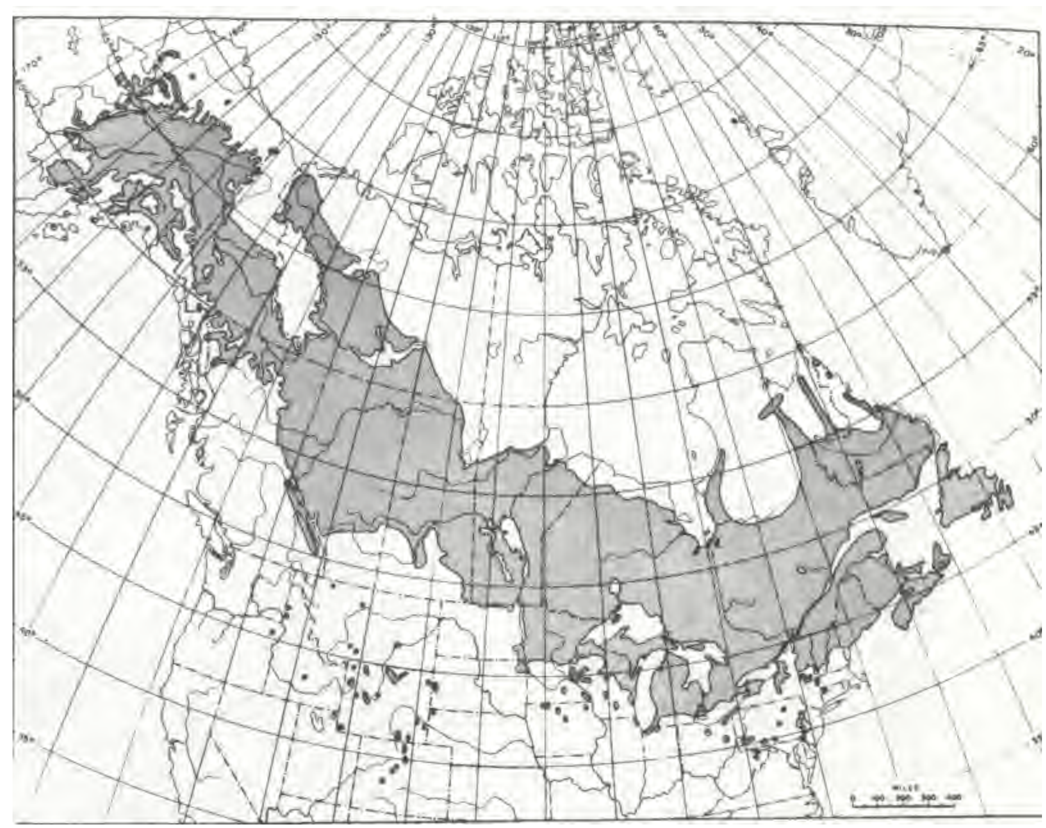

Figure 11.--The natural range of Populus balsamifera L.

Short-term provenance trials, recommended in a IUFRO report by Lines (1967), would be particularly suitable for combination provenance-gene pool plantations because they are designed for valid provenance results until the time when major competition sets in.

Productivity of Controlled Breeding Methods - Large-scale poplar breeding should be carried out in the greenhouse (figure 13). Dormant flowering branches can be stored under refrigeration, placed in water or potting soil to flower, and then pollinated to produce an ample abundance of seed within a few weeks. In "Genetics of eastern cottonwood" (Schreiner 1970), I have used a flow chart to illustrate possible procedures for plus tree selection, intraspecific breeding, and species hybridization.

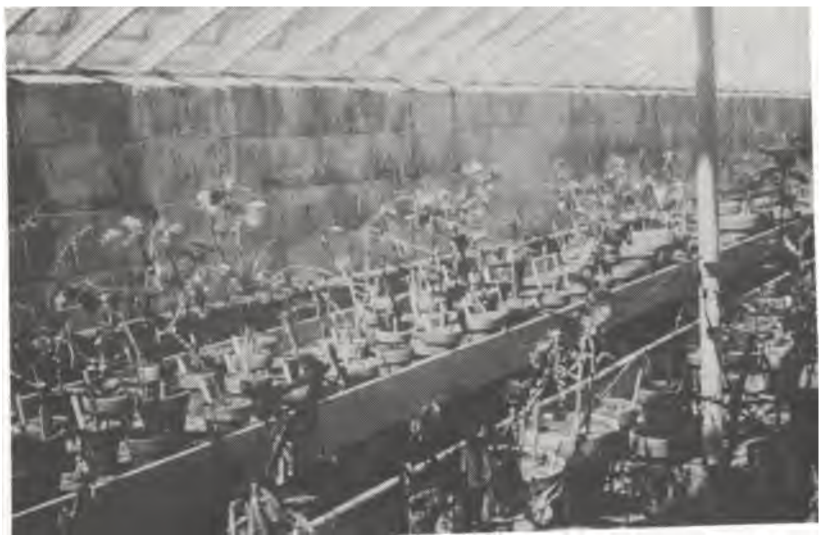

Figure 13.--Second generation breeding with poplars in the greenhouse.

Species Crossability - There apparently are relatively few important barriers to species crossabilities not only within taxonomic SECTIONS but also between members of different SECTIONS; the first evidence, based on controlled pollinations, was reported by Stout and Schreiner (1933). In this paper we listed the parentages of approximately 13,000 hybrids produced in 1925 and 1926. These included both intra- and intersectional crosses.

Where barriers between species are encountered it may be possible to obtain the desired combinations by the use of irradiated mentor pollen (Stettler, 1968), through bridging crosses (Burnham, 1966), autotriploidy (Moav, 1962) or embryo culture.

Feasibility of Clonal Propagation - The ability of poplars to root from cuttings varies greatly among and within species, but available evidence indicates that economically feasible rooting ability can be bred into poor-rooting species. The most rapid progress in forest tree improvement will be based on the use of multiclonal hybrid varieties.

I presented my views on this problem at the International Meeting on Biology of Rust Resistance in Forest Trees (Schreiner 1972a).

Multiclonal hybrid varieties would be mixtures of clones (intra- or interspecific hybrids or both) selected for a high degree of vegetative fitness and for special traits, such as rapid growth, resistance to pests, timber form, and growth habit. The genetic gain will depend on the average performance of genetically superior individuals, not on the average performance of families or lines. Exceptionally superior individuals may be obtained in early generations of intensive breeding or by intensive selection in progenies derived from gene pools or natural populations. The clones in a multiclonal variety could be changed on very short notice, because the breeder could multiply superior clones for commercial use without adulteration of the genotype, and without determining their combining ability to transmit the desirable qualities or characteristics.

Periodicity and Age of Flowering - Most, if not all, poplars bloom every year. They begin to bloom between 5 and 15 years of age depending in considerable measure on the environmental conditions under which they are grown.

Length of Progeny Test Period - Poplar progenies should be tested for at least 4 years for mini-rotation fiber production. For longer rotations, such as boltwood or lumber and veneer timber, they should be tested for half the rotation for which they are selected.

The Northeastern Forest Experiment Station released 40 clones from a 15-year clonal test in Williamstown, Massachusetts, to State Forest Nurseries for commercial trials in the Northeastern Region (Schreiner 1972b). It should be noted that the release of clones based on such a geographically limited clonal test should be for commercial trials, not for guaranteed commercial performance.

These clones were selected on the basis of 95 percent to 100 percent rooting ability; height at 4, 9 or 10, and 15 years; and mean annual increment on all replicates and on the best replicate on each site. Field-resistance ratings (to leaf diseases and stem cankers) were based on the probability of a profitable harvest on suitable poplar sites for a fiber mini-rotation of 4 years, a boltwood rotation of 9 to 15 years, and a timber rotation up to 25 years.

Some of these hybrids had also demonstrated their usefulness in amenity plantings and for reforestation of strip-mine spoil banks.

SUMMARY

My summary will be very brief:

1. The genus *Populus* offers greater possibilities for genetic improvement than any other genus of forest trees.

2. The possibilities for genetic improvement of poplars justify at least a 10-fold increase in the present world-wide breeding work with this genus.

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POST CONFERENCE TOURS

Following the technical and business sessions of the Commit Forest Tree Breeding in Canada and the Northeastern Forest Tree Improvement Conference, many of the members participated in one or both of the scheduled field trips.

The first tour wound up along the Nashwaak-Miramichi Trait (N.B. Rt. #8) to the Acadia Experimental Forest. George MacGillivray and other staff members explained the nursery operations and reviewed the major studies underway. The remainder of the afternoon was used for a walking tour of various outplantings on the Experimental Forest. Frequent stops provided an opportunity for lively discussions on the relative merits of various species and the improvement schemes being used. Cold liquid refreshment was provided at each stop by our congenial hosts.

A large contingent journeyed to the St. Quentin-St. Leonard area about 200 miles northwest of Fredericton the following day to visit forestry operations of J. D. Irving, Ltd. A tour of the Black Brook Unit (approximately 600,000 acres of freehold land) was led by Neils H. Kreiberg, Reforestation Forester, who explained the sequence of operations culminating in successful plantation establishment.

The topography of the Black Brook Unit is flat to gently rolling and the soil is predominantly a weathered shale that tends to break up easily. It is possible to construct exceptionally good roads that do not require surfacing and produce minimal erosion in this area.

The first step to achieve maximum productivity on the site is to remove the old growth understocked stands. Trees are either cut into log or full-tree length and trucked to a Company mill where small or defective logs are run through gang saws and better grade material is sawed for quality in a modern circular mill. All tops, slabs, and edgings are chipped, blown into railroad cars and transported to the pulp mill. At the present time a few narrow strips of timber are being left uncut (in areas of high visibility) for aesthetic purposes as well as for wind breaks and fire belts.

Following the logging operation, the land is prepared for planting with large tree crushers. Irving presently uses three units ranging in size from 40 to 150 tons. The smaller machine produces a prepared strip 26 feet in width on each pass and is capable of clearing 30 acres a day. Preferably, the crushing operation should take place several years after logging and also a couple of years prior to planting. The crushing serves primarily to flatten the slash and logging debris so as to make the land accessible to the planters. A second advantage is seen in the accelerated recycling of organic material pushed into the upper soil layers. There is no compaction and practically no scarification. The organic layer is quite shallow and considered too precious for general churning.

Seedlings are grown in the Juniper Nursery on the Maramichi River with most of the seed being collected from the area where it is to be planted. Over nine million seedlings were planted in 1973. Production costs and planting costs are about equal with an eight-cent outlay from seed to planted seedlings. In addition to bareroot seedlings, one or two million seedlings are grown in degradeable paper tubes and are planted by dropping the seedling into a hand-operated planting tube. The species planted are white, black, and red spruce with more emphasis on the first two.

J. D. Irving, Ltd. is justifiably proud of the fact that they are already planting more trees each year than they are cutting. With the possible exception of a few large corporations in the southern United States, no other organization can make that claim.

A fleet of planes equipped with spray booms is used to release the plantations from competing vegetation and to control any outbreaks of spruce budworm that may occur.

Irving foresters are working closely with the genetics group at Fredericton to find even faster growing spruce for their program. Two seed orchards (black spruce) have been established together with several seed production stands.

The entire genetics group wishes to express its appreciation for the time and effort spent by each of the Irving staff, especially Neils Kreiberg and Pat Marceau for making the tour so interesting. Our thanks also to the planting crew for their demonstration and to the chefs for a most excellent multi-course luncheon.

ACADIA EXPERIMENTAL FOREST

Power bucket used in spruce breeding program on Acadia Experimental Forest.

George MacGillivray discussing a black spruce provenance test in the Acadia Experimental Forest nursery.

Norway spruce provenance trial on Acadia Experimental Forest. Trees 17 years from seed.

Provenance trial of three larch species on Acadia Experimental Forest. Trees 15 years from see

Load of logs leaving Black Brook unit for J. D. Irving, Ltd. Mill.

Fifty-ton crusher. Bar is for pushing over residual trees and drum-type wheels crush woody material on ground.

View of crusher illustrating site before treatment (background) and following crushing operation.

Site prepared for planting. Large stump in center of photograph has been pushed into the ground by the weight of the crusher.

Planting crew demonstrating methods used to obtain uniform plantation spacing.

String lines being moved ahead of a planting crew on Black Brook Unit.

Vigorously growing black spruce six years after planting on Black Brook Unit.

General topographic features of Black Brook Unit and size of individual planting blocks.