THE PRESENT STATUS OF FOREST TREE BREEDING IN CANADA

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Two main phases of forest tree breeding are commonly recognized, namely the conservational phase and the individual selection phase. The conservational phase aims at conserving and perpetuating the best germ plasm of existing tree populations, usually by means of various cutting methods

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directed towards the most successful natural regeneration of such popelations. Methods of bulk selection are used and superior existing stands are sometimes selected and managed for seed production. The seed thus obtained is used in both natural and artificial regeneration.

The individual selection phase is supposed to serve the needs of artificial regeneration in providing seeds of superior genetic quality collected from selected individual trees, either directly or from so-called seed orchards where such trees are propagated vegetatively and managed in such a manner that the resulting seed material is more abundant and genetically superior to that obtainable from natural stands.

In Canada, we are at present chiefly concerned with the individual selection phase of forest tree breeding. Our chief aim is to serve the needs of artificial regeneration and to supply seed or plant material that from a genetic standpoint is best suited for such needs. Our tree breeding activities are closely linked with tree planting activities and are centered in areas where such activities have created a demand for planting stock of superior genetic quality. From 1939 to 1952, all forest tree breeding work in Canada was carried out in cooperation with the Subcommittee on Forest Tree Breeding of the Associate Committee on Forestry of the National Research Council of Canada. In 1952, the Associate Committee on Forestry was disbanded and the Director of Forestry, Department of Resources and Development, assumed the responsibility for the activities of the Subcommittee.

WORK IN BRITISH COLUMBIA

In a short description of tree breeding activities in Canada, I will start at the west coast and begin with the work of W. A. Porter in British Columbia. Mr. Porter is employed by the Canada Department of Agriculture and is selecting western white pine for resistance to blister rust. A sizable tree planting program is under way on the coast of British Columbia, and several forest nurseries are operated in this connection by the Provincial Government. The main species planted on cutover areas that lack satisfactory natural regeneration are Douglas fir and Sitka spruce. Western white pine is admittedly a very valuable species. It could be raised in the same nurseries and planted along with the other two species with very good economic results, if we had plant material that we knew would survive under natural conditions. With such plant material we could hope to increase the proportion of white pine in the coast forest and thus as a whole tend to produce more diversified and valuable kinds of trees.

Mr. Porter is at present engaged in the selection of seemingly resistant individual western white pines in the more accessible coast forests. The material is grafted on stock imported from the Savenac nursery in Montana, and the grafts will be tested in a disease garden with Ribes and in a climate that is very favorable to the natural infection of white pine by blister rust. Later, material from the interior of British Columbia will be included in the tests, and there will also be a chance to test some of our eastern selections for resistance. If and when good resistant material has been selected and tested, it will most probably be used, in one way or another, for seed production. The seed produced in this manner will be in good demand by the existing forest nurseries, and elsewhere.

WORK IN SASKATCHEWAN

Dr. W. H. Cram is working at the Forest Nursery Station, Indian Head, Saskatchewan. The Forest Nursery Station is operated by the Canada Department of Agriculture and is distributing planting stock for prairie shelterbelts. There is a need for better climatic and soil adaptation as well as more vigorous growth in the species used for this purpose. The main species concerned is Caragana arborescens, a shrub native to Siberia and now widely used for shelterbelts in the prairies. Self-sterile individuals of vigorous growth are being selected, tested for combining ability and seed producing capacity , and propagated vegetatively for the establishment of seed production units. Rather wide variation in several important characters has been found within the material of this species introduced thus far into the Canadian prairies, and additional material is being assembled from the United States and elsewhere. Several inbred progenies have been produced and are being tested.

Work with white, Black Hills, Norway, and Colorado spruces presently consists largely of the seedbed performance of one-parent progenies of selected trees. Variation in the stratification requirement of the seeds, and in the proportion of good nursery transplants produced has been found. The material is being subjected to further tests for vigor and adaptability. White spruce enters the southern prairies both from the west and from the east, besides being native to the northern prairies. Several taxonomically distinct forms occur in different regions and offer a wide scope for hybridization and selection of superior types. Colorado spruce is also being used in prairie shelterbelts and lends itself well to further improvement in adaptation to such a new habitat.

Work with Scotch pine is proceeding along similar lines. Material of different geographic origin and of seed-bearing age is at hand. Nursery performance tests with one-parent progenies of this material are under way. Later, such progenies will be tested for their performance in shelterbelts. Similar work with Manitoba maple (boxelder) is also in progress, on a rather small scale thus far.

Various poplars of the cottonwood and balsam poplar groups are being widely planted in prairie shelterbelts, and a fairly large collection of different clones and seedling populations of this kind has been assembled at Indian Head. The native cottonwoods root very poorly from stem cuttings and many of the so-called Russian poplars are subject to canker. The northwest poplar, a natural hybrid from North Dakota, has been widely planted in recent years, but roots rather poorly from stem cuttings and is a slow grower. Hybrids of various native poplars and

Russian poplars have been obtained and are being tested for rooting capacity from stem cuttings and general performance in shelterbelts.

WORK AT PETAWAWA

The work of M. Hoist at the Petawawa Forest Experiment Station, Chalk River, Ontario, is being described in a separate paper and, therefore, it is only mentioned here that he works with spruce, hard pines, and larch.

WORK AT THE CENTRAL EXPERIMENTAL FARM

Dr. A. W. S. Hunter, of the Division of Horticulture, Central Experimental Farm, Ottawa, has in recent years started some work in breeding for resistance to Dutch elm disease. Crosses between the diploid *Ulmus pumila* and the tetraploid *Ulmus americana* are being tried. Ulmus pumila is being treated with colchicine to induce chromosome doubling, and apparently resistant Dutch elm varieties have been imported. At the Dominion Experimental Station, L'Assomption, Quebec, white elm seedlings are being artificially inoculated with Dutch elm disease and methods of vegetative propagation of elm worked out. Dr. Hunter has also produced some black currant x red currant hybrids for my work with blister rust resistance in white pine.

WORK AT THE SOUTHERN EXPERIMENT STATION

My own work is being carried out at the Southern Experiment Station, Maple, Ontario, under the direction of the Division of Research, Ontario Departmentof Lands and Forests, and is, in part, supported by grants from the Ontario Research Council. It is concerned with white pine, aspen poplars, and, more recently, with 2-needled pines. The work is closely connected with our Division of Reforestation which operates several nurseries that supply planting stock to farmers and to county any' municipal forests. It also collects seed and operates a seed extraction plant. There are fairly large areas of abandoned farm land on light soil in southern and central Ontario that are gradually being replanted with stock produced by these nurseries. Planting is also being done on some cut-over and burned areas with insufficient natural regeneration.

White Pine Studies

White pine was one of the main species raised and planted at the beginning of reforestation activities in the early part of this century, but blister rust and weevil soon restricted the use of this very valuable species. Work in selection for resistance to blister rust follows the lines already established by Dr. A. J. Riker in Wisconsin. Grafts are being produced in the greenhouse and outside with scions collected from trees that are free from the disease under conditions of severe natural infection. These grafts are being set out in special beds that can be covered with lath screens and burlap, and subjected to artificial inoculation. Black currants are being grown in a lath house to supply the necessary inoculum.

The plantation of white pine at Pointe Platon, Quebec, is our main source of resistant materials. In addition, we have obtained scions and seeds from apparently resistant trees in Denmark and Germany, as well as some of Dr. Biker's selected clones. Cooperation with the Northwestern Blister Rust Control Project of the U. S. Department of Agriculture in Spokane was initiated in 1951, and we are at present growing and testing some of their supposedly resistant western white pine selections and are sending them some of our selections. An exchange of pollen with various organizations in the United States and Europe is also under way. The work is being coordinated and kept up to date by the Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U.S.D.A., Washington, D.C., which receives and distributes reports from workers with blister rust in white pines in the United States and Canada.

The white pine weevil is being taken care of by selecting outstanding trees, free from weevil attack but growing under conditions of severe weevil infestation, in plantations and natural stands. Grafts from such trees are first subjected to the standard tests for resistance to blister rust and studied with respect to leader thickness. The so—called slender leader trees of the entomologists have been found to be less susceptible to weevil attacks than trees with thick leaders. Leader thickness is admittedly a character that is strongly influenced by the environment, and the grafts at first show a rather strong influence of the size of the original scions on their shoot thickness. Later, inherent differences in shoot thickness become apparent and the different clones become more uniform in this respect. The material is grafted on rather uniform stock and is growing under uniform conditions in the nursery.

The native white pine is further being analyzed in respect to its segregation into ecotypes and climatic races by means of strain tests. In the fall of 1946, a fairly large seed collection was undertaken in different parts of Ontario and seeds from selected trees, selected stands, and bulk collections from several localities were assembled and later sown in three of the Provincial forest nurseries. The resulting material, about 200 thousand plants, was set out in 25 test plantations located in southern and central Ontario, and one in Quebec.

One strain of western white pine and seeds from the plantation at Pointe Platon, Quebec, are included in this. The plants are set out in replicated lots at a spacing of 4x5 feet, to provide material for very early thinning and individual selection. These strain tests have already yielded preliminary information in respect to inherent superiority in growth form and growth rate, about the most promising localities for seed collection, for reforestation purposes.

In addition to working with pure eastern and western white pines, other species and hybrids of 5-needled pines are being assembled, tested for resistance to blister rust and weeviling, and evaluated in respect to other characters. Material of this kind has been obtained from several arboreta, parks and botanical gardens in the United States and in Europe. Some such hybrids have been produced at Maple. Of these, Pinus pence and its hybrids with eastern white pine are particularly promising because of their high degree of resistance to blister rust and their early flowering. The resistance to blister rust seems to have a different genetic basis from that of eastern white pine. The early flowering might be a valuable character in the production of stock for grafting, to induce early flowering in other breeding materials of white pine. It is possible that other valuable characters can be obtained from Pinus Griffithii, the Himalayan white pine, and Pinus parviflora, the Japanese white pine. Both are crossable with. the North American white pines and we have hybrids at hand. An evaluation in this respect of the Appalachian white pine has just been started.

Aspen Studies

In contrast to the work with white pine, the work with aspen poplars is at present not directly connected with the reforestation activities of our Department. It is an outgrowth of former work with the breeding of poplars for shelterbelts in the prairies. We happened to produce something that was valuable and are receiving further requests for poplars suitable for the production of match stock and pulpwood. As aspens usually yield better match stock than cottonwoods and balsam poplars and their hybrids, and also can grow on medium fertile soils that usually are more available to forest industries in Ontario, the breeding work at the present time is concerned only with aspens and their hybrids.

Of the native aspens, P. tremuloides is the most widely distributed in Ontario. We have very good material of this species in northern and especially in northwestern Ontario. This material has yielded very promising hybrids with northern forms of European aspen in Sweden. Promising results have also been obtained by crossing good trembling aspen from northern Minnesota with P. adenopoda, a Chinese aspen found planted in Rochester, New York. Northern trembling aspen does not grow well when planted in southern Ontario, probably because its day length requirements are not satisfied. Trembling aspen, native to southern Ontario, has been crossed with Polish aspen in Denmark, and some of the resulting very heterogeneous hybrid seedlings seem to be of promise to us. In recent years, we have been sending pollen of trembling aspen in increasing quantities to Europe, especially to the Scandinavian countries, for the production of hybrid aspens to be grown there for match stock. A dwarf form of trembling aspen that flowers very early in life has been found in southern Ontario, and this form is now being put into use as dwarfing stock to induce early flowering in other aspen materials. Some western forms of tembling aspen have also been obtained and tested, but these are susceptible to a Melampsora rust under our conditions.

The other native species, P. grandidentata, does not seem to be as dependent on day length as P. tremuloides and we have successfully moved material from the northernmost parts of its range, as well as from the southernmost parts in the United States, to southern Ontario. This species grows well on light sandy soils, and for this reason appears to be promising for planting work.

It hybridizes easily with P. alba, the silver poplar, and natural hybrids are found abundantly wherever the latter species is planted. Only a very small proportion of such hybrids seem capable of growing into large trees, however. The greater part soon become stagheaded and decadent under natural conditions, although they all grow very well in a cultivated nursery. The cross P. alba x grandidentata has been made artificially several times, using different P. alba materials for this purpose, and has yielded seedlings quite similar to those found in nature. Some of the oldest and largest natural hybrids of this kind have been taken into cultivation and appear to be most promising under our conditions. The crosses P. canescens x grandidentata and P. tomentosa x grandidentata have also been made and have yielded more aspen—like hybrids than P. alba x grandidentata. They grow very well with us but are as yet too young for any determination of their forest quality.

European aspen, P. tremula, has been introduced from several parts of Europe and a population from Czechoslovakia, of excellent growth form, has shown such good growth that we are starting to propagate it for tests on a larger scale. This species is sometimes badly chewed by grasshoppers when young plants are set out in grassy areas, in contrast to the native aspen species. Thus far, it has not been attacked by Hypoxylon canker, to which P. alba and some forms of P. canescens seem highly susceptible. We have also obtained some of the Swedish triploid aspens, and these grow quite well and flower abundantly with us, although thus far the growth 1.s not superior to that of our best native aspen materials.

We thus have abundant aspen materials at hand for a very promising breeding program, and also clones of pure species and hybrids that could immediately be put to work in producing good match stock and pulpwood, were it not for a major bottleneck. This bottleneck is the problem of propagation. Aspens are notoriously difficult to grow from seeds and many difficulties are encountered in raising hybrid seedlings. This can only be done by using very intensive horticultural techniques and is thus far not economically feasible on an industrial scale. It is possible, however, that soil conditioning agents and fungicides in time will help us in solving this problem. Aspens cannot be propagated by stem cuttings by direct planting in a nursery. It has been possible to root stem cuttings of aspens with the aid of plant growth hormones in specially prepared propagation beds, but as yet not on an industrial scale. Propagation by means of root cuttings is quite feasible and has been put into practice with several forms of P. canescens in Europe, but we have not found this practical under our conditions. Grafting of aspens on rooted cuttings of P. alba is also quite feasible but probably too expensive for industrial application. Budding has not been successful to any degree in our hot summers. It is possible that bench-grafting of aspen cuttings on to cuttings of P. alba with good rooting capacity in time might be perfected to such a degree that it will lend itself to industrial application. This is the most promising approach to date, and we are working on it.

I believe the ultimate solution of the propagation problem lies in the breeding of aspen hybrids with satisfactory rooting capacity from stem cuttings and otherwise acceptable as planting materials for match stock and pulpwood production. We have found P. alba with good rooting capacity planted in Ontario, of which breeding materials are available. We have also obtained a population of P. alba of Hungarian origin, of excellent growth form, and are each year obtaining additional P. alba materials from Europe and elsewhere, for further tests. We have found that rooting capacity of P. alba is partially dominant in crosses with aspens. The crosses P. alba x grandidentata and P. alba x tremula are particularly promising in this respect, and in exhibiting hybrid vigor. It still remains to combine the useful characters of P. alba and available aspen materials in such a manner that they will produce aspen—like hybrids with good rooting capacity from stem cuttings. This will necessarily require the raising of more than one generation of hybrids and, even with the best techniques available, take some time.

Hard Pine Studies

The work with red pine and other 2—needled pines is again closely tied in with reforestation. At the beginning of my work at Maple, Ontario, some 6 – 7 years ago, the problem was purely quantitative: we needed more red pine seed for our nurseries and experiments were started to increase seed production of young red pine plantations. Intensive thinning and partial girdling have given very promising results in this respect.

In recent years, the European pine shoot moth has been damaging young red pine and Scotch pine in southern Ontario so much that it has become a serious problem. The breeding of a red pine having resistance to the shoot moth is highly desirable. It probably will be very difficult, if not impossible, to accomplish this through selection alone. Thus far, it has not been possible to cross red pine with another pine species of the Lariciones group, to which it belongs, although all the possibilities have by far not been tried out in this respect. It may also be possible to work with Austrian pine which has some resistance to the shoot moth, and with this species as a basis to produce hybrid 2—needled pines suitable for replacing red pine and Scotch pine in areas where the shoot moth is now a problem. This looks like a long—term project, but it is well worth while, because southern Ontario is by no means the only area where the pine shoot moth has become a serious problem. This latter phase is now being carried out in cooperation with Mr. Holst.

Future Trends

As abandoned farm lands will be planted up, reforestation activities in southern Ontario are bound to decrease. As the population increases, more intensive silvicultural and management, methods will be economically possible on a wide area further to the north, and other research stations might then conceivably be established there. Then the present work will supply a background of technical experience in the individual selection phase of forest tree breeding. At that time we also should be thinking more about the conservational phase than at present. This will apply particularly to the management of the more tolerant tree species by means of various kinds of selective cutting, with artificial regeneration supplementing existing natural regeneration.