FOREST TREE IMPROVEMENT PROGRAM FOR THE NATIONAL FORESTS IN THE LAKE STATES

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ABSTRACT.--The Eastern Region of the USDA Forest Service has been conducting a Forest Tree Improvement Program on the national forests in the Lake States since the early 1960's. This paper presents a general review of the program, including objectives, organization, species priorities, and basic steps and procedures. Also discusses accomplishments and future plans.

A tree improvement program for the more than 5.6 million acres of commercial forest land on the eight national forests in the Lake States was begun in the early 1960's. Objectives for the program are: (1) to develop an aggressive, practical tree improvement program; (2) to produce seed for seedling production and/or direct seeding that will yield fast-growing, high-quality, pest-resistant forest trees; and (3) to develop and demonstrate cultural methods for producing timber and other products by applying sound genetic principles.

The program is carried on by a Regional Geneticist, a Zone Geneticist; in addition each forest has one or more technicians. The Regional Geneticist develops and coordinates the tree improvement, nursery , and seed procurement programs. The Zone Geneticist implements and coordinates the tree improvement program which includes training and supervising a full-time seed orchard manager, training technicians for each national forest, and keeping all personnel informed of progress and status of the tree improvement program. The technicians perform the initial screening of superior tree selections, do the seed and scion collection work, and assist in collecting data and maintaining records.

SPECIES

The first step in the program was to establish species priorities and program intensities. Factors considered included acres of commercial forest land in the various timber types, genetic variation within the species, plantability of the species, current research programs, estimated

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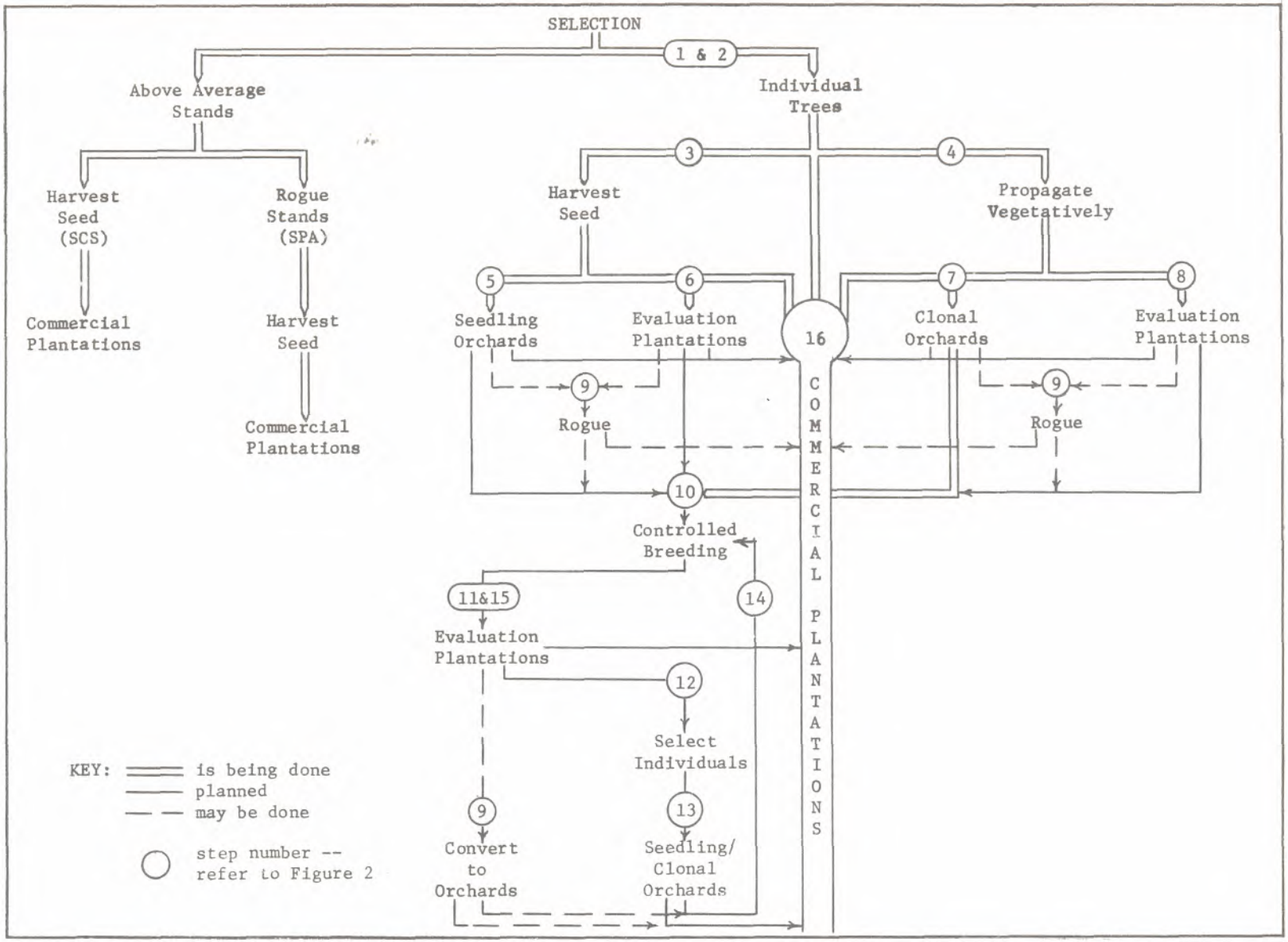

Figure 1.--Basic steps in the Region 9 forest tree improvement program.

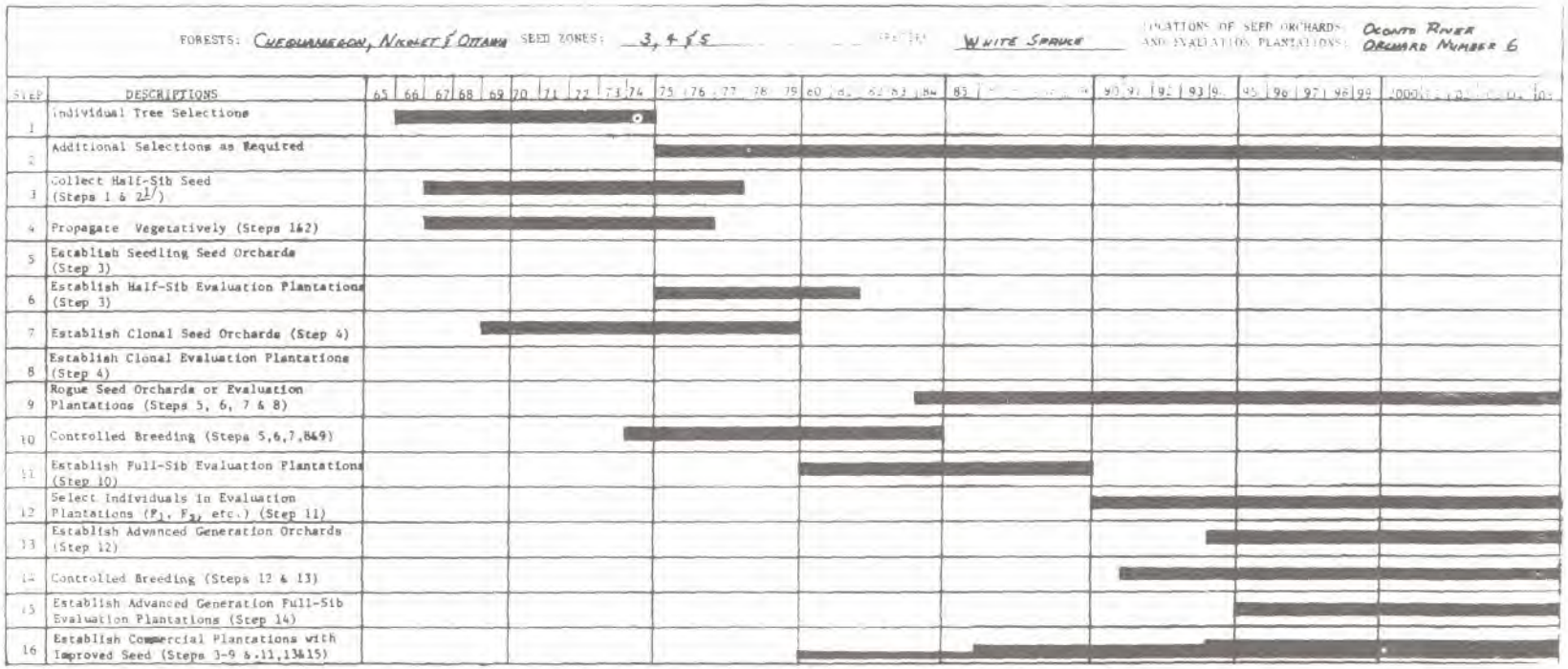

Figure 2.--Region 9 forest tree improvement time schedule for white spruce on the Chequamegon, Nicolet and Ottawa National Forests. The schedule indicates the time span for those steps applicable to the intensity of the program. (1/ The numbers in parenthesis refer to previous steps that this action is dependent on.)

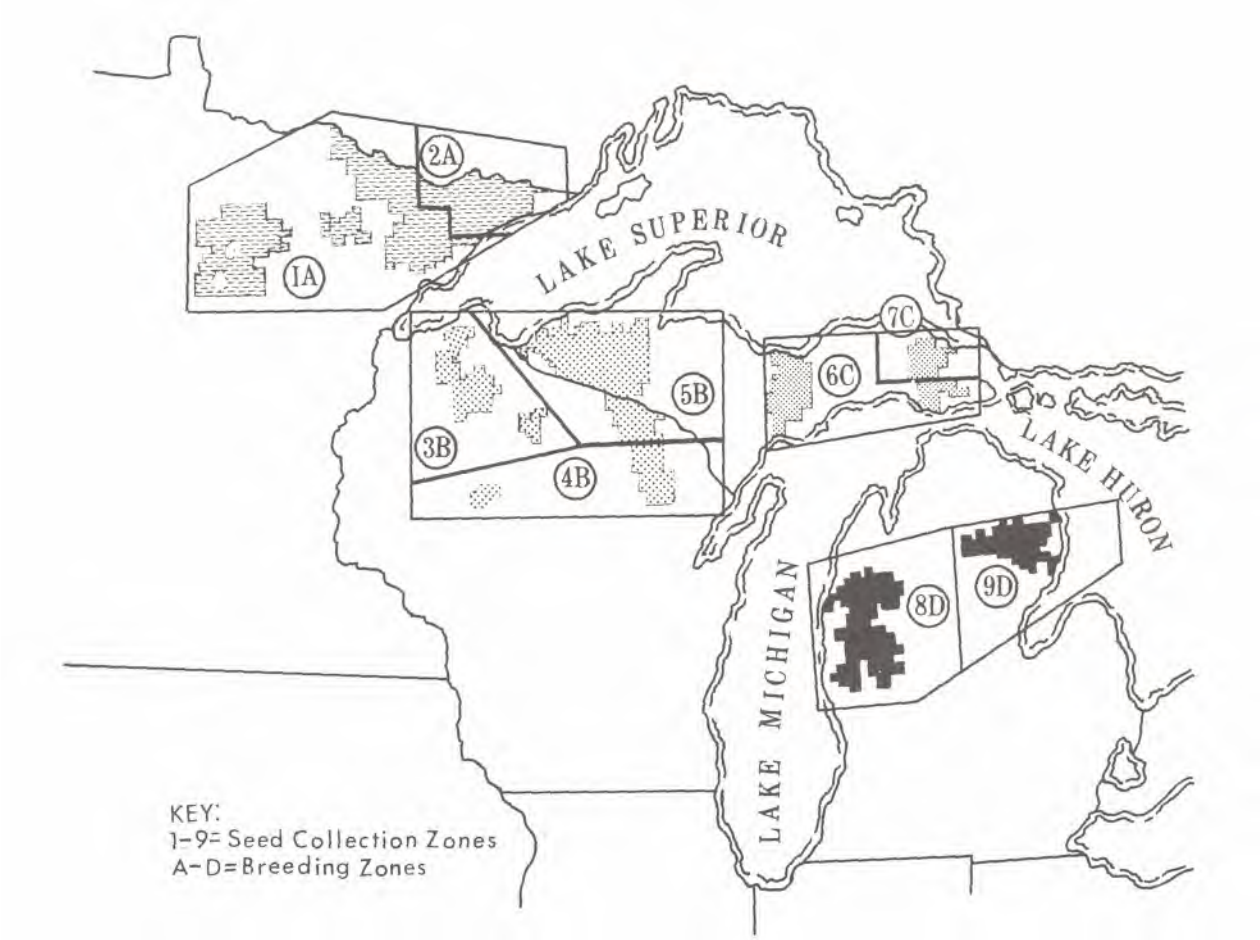

Figure 3.--Seed collection zones and breeding zones.

economic gains, and, to some extent, development programs carried on by others (table 1).

Table 1.--Species priority and types of programs

Species (in order of priority)	Priority group	Program: SCS and SPA	Selection	Seed orchard	Breeding	Evaluation plantation
White Pine	A		X	X	X	X
White Spruce	A	X	X	X	X	X
Aspen	A					X
Jack Pine	A	X	X	X	X	X
Black Spruce	A	X	X	X	X	X
Red Pine	A	X	X	X	X	X
Yellow Birch	A		X	X	X	X
Paper Birch	B		X			X
Black Cherry	B		X			X
Sugar Maple	B		X			X
Red Oak	C		X			X
Basswood	C		X			X
Red Maple	C		X			X
Larch	C		X			X

The program has been divided into 16 basic steps.(fig. 1). The program for each species varies considerably in scope and degree. Time schedules are used to show the anticipated work for each species and to coordinate the work that involves several species over a period of years. The schedule for white spruce (fig. 2) is one of the most involved.

SEED COLLECTION ZONES AND BREEDING ZONES

The second major action in the program was to delineate seed collection zones for the eight national forests (fig. 3). The zones are based on the average January temperature and the total number of degree days above 50°F during the growing season (Rudolf 1956). To simplify the establishment of the seed orchards, the nine seed collection zones have been combined into four breeding zones.(fig. 3). These breeding zones are based on the desired adaptability of the improved materials and may have to be modified as data become available from evaluation plantations.

SEED COLLECTION

Seed collection stands (SCS) have been located for black spruce and red pine within each seed collection zone. Timber sales within these selected stands are coordinated with good seed crops, and cones are

collected from the downed tops. White spruce and red pine seed, production areas (SPA) were established in each seed zone where the species occurred naturally. Cones have been collected in the white spruce SPA's during good crop years by shooting or cutting the tops out of selected trees and picking the cones off the tops on the ground. The trees usually produce four to six new tops and another bumper cone crop within 6 years. Nienstaedt 2/ has included white spruce seed collected from one of the SPA's in his research and found that the SPA seedlings were 10 percent taller than the control seedlot at age 4. Small amounts of seed have been harvested in the red pine SPA's, mainly by climbing the trees. Collecting red pine cones in SPA's has been more difficult and expensive than similar work in white spruce SPA's. The time is rapidly approaching when all seed used on national forest land will originate from SCS, SPA, or individual tree collections.

SELECTION

Individual trees exhibiting fast growth, good form, and pest resistance are located on each national forest by trained technicians. Comparison trees are used to guide selection. Although there are inherent weaknesses in this process, comparison trees do provide a guide for the initial phases of the selection work (Ledig 1974). As workers become more familiar with the selection process, they depend less on comparison trees and more on how the candidate compares with previous selections. Several outstanding trees have been included in the program based on their own merit. More than 2,000 selections representing 11 species have been made.

VEGETATIVE PROPAGATION

All grafts are made at the J. W. Tourney Nursery, Watersmeet, Michigan, or at the Oconto River Seed Orchard. The scion collection work during January and February is closely coordinated with the grafting operation, enabling the grafting of all scions within 7 days of collection. The completed grafts are removed from their pots and lined out at the nursery or seed orchard after the danger of frost is past. The grafts are cared for from 1 to 3 years, depending on the species, and then moved to their specific seed orchard. Between 1969 and 1973, grafting success averaged 87 percent for white pine, 74 percent for white spruce, 81 percent for black spruce, and 83 percent for yellow birch. During the past 2 years, secondary scions have been collected from established grafts growing in the seed orchard. There has been no problem with graft incompatibility.

SEED ORCHARD

In 1967, we consolidated all seed orchards for the Lake States national forests in one area called the Oconto River Seed Orchard. about 30 miles

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east of Antigo, Wisconsin on the Nicolet National Forest. This made it possible to employ and train a crew, as well as purchase the necessary equipment and supplies to intensively manage the seed orchard. The area includes 500 acres of cultivated farmland, 180 acres of woodland, a pond, and a trout stream.

During the summer of 1968, a survey crew established a grid system and constructed a topographic map using a 1-foot contour interval. Soil pits were dug adjacent to several grid stakes, and soil types were plotted on the topographic map. The soil in the cultivated fields is mostly Antigo silt loam, deep and shallow phases. This is an excellent agricultural soil and no fertilization was recommended for tree species at the time. A deer exclosure fence was erected around the entire section in the summer of 1969. The administrative site, including warehouse, office, headhouse, and greenhouse, was developed between 1970 and 1974. The warehouse also serves as an inoculation chamber for the blister rust-resistant eastern white pine program.

Pollen contamination among seed orchards of a particular species is reduced by locating the individual orchards far apart and by planting orchards of other species between them. The wooded areas, composed mainly of aspen, maple, and balsam fir, also serve to reduce pollen contamination.

The first seed orchards were established on cultivated fields during the spring of 1969. A computer program developed by Stairs et al. at the University of Wisconsin was used to generate a completely random planting design that maximizes out-crossing. The grafts are planted, staggered 30 feet apart in rows 15 feet apart--an actual spacing of about 22 feet by 22 feet. The initial orchards were kept clean-cultivated for about 3 years, and the grass was mowed around several extra grafts that were planted at a 10 feet by 10 feet spacing. Because the cone production on clones (white pine and white spruce) growing in both mowed and cultivated seed orchards seemed to be about the same, cultivation was reduced and the orchards were seeded to grass. Now the grafts are planted in the sod, the area around each graft is treated with an herbicide, and a mulch of sawdust or other suitable material is placed around the grafts. This method has increased accessibility within the orchards, reduced maintenance costs, and maintained excellent survival and growth.

Cone production in the white and black spruce and white pine orchards has been increasing each year. In 1974 it ranged from 18 to 31 percent of the total number of grafts in two white pine orchards, from 12 to 55 percent in white spruce and from 2 to 41 percent in black spruce. White pine and black spruce produced no male strobili. Most of the seed collected in the orchards is being reserved for establishing evaluation plantations.

The eastern white pine blister rust-resistant development program is also centered at the Oconto River Seed Orchard (Miller 1972).

EVALUATION PLANTATIONS

The evaluation plantations, like the seed orchards, are being consolidated as much as possible to facilitate the work and ensure proper care. Five major evaluation sites have been selected--one in Minnesota, Upper Michigan, and Lower Michigan, and two in Wisconsin.

Efforts have been concentrated on producing and evaluating full-sib material, but half-sib evaluation plantations are planned for white spruce, black spruce, and jack pine. Whenever possible, plant materials will be evaluated in each of the five major evaluation plantation sites. One objective is to identify material that will perform well in several of the sites. Seedlots that produced these selected materials would be sown in the nursery each year as a small part of the normal production and used within appropriate zones where stock shortages exist.

CONTROLLED POLLINATION

After reviewing several mating designs, it was decided to use a multiple four-parent disconnected half diallel (Squillace 1973). This design provides great flexibility in making crosses within and among the seed orchards for specific zones, with the production of a minimum number of half-sib families. In order to broaden the genetic base of the breeding program, the program was developed in cooperation with the North Central Forest Experiment Station, Institute of Forest Genetics, and will include their selections. This design was used in the white spruce breeding program, which began in the spring of 1975.

Evaluation plantations will be established as the full-sib seed becomes available from a sufficient number of crosses. As soon as the trees begin to flower, selections will be made in these plantation and used to upgrade existing orchards and/or establish new ones, and will also be included in an advanced generation breeding program. The main objective will be to create new generations as rapidly as possible with the available material and data. The older plantations will continue to be evaluated and new selections added to, or previous selections eliminated from, the breeding programs and seed orchards. This will result in a continuous genetic gain in the seed orchards.

RECORDS

An ADP system has been developed to help maintain the identity and status of all plant material used in the tree improvement program. The system also summarizes and analyzes the data collected in seed orchards, evaluation plantations, and breeding programs.

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