STATION PAPER NO. 20

DECEMBER 1952

SUGGESTED PROJECTS IN THE GENETIC IMPROVEMENT OF SOUTHERN FOREST TREES

BY

THE COMMITTEE ON SOUTHERN FOREST TREE IMPROVEMENT

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE SERVICE

U. S. Department of Agriculture

Southeastern Forest Experiment Station

Asheville, North Carolina

E. L. Demmon,

Director

This publication was prepared by the Committee on Southern Forest Tree Improvement to assist those who might take part in forest genetics research.

Previous publications and reports prepared by or for the committee are:

1. Report of the first southern conference on forest tree improvement. Atlanta, Ga., January 9-10, 1951. Mimeographed. U. S. Forest Service, Atlanta, Ga.

2. Proposal for a cooperative study of geographic sources of southern pine seed. Subcommittee on Geographic Source of Seed, Philip C. Wakeley, Chairman. Mimeographed. Southern Forest Experiment Station, New Orleans, La. Oct. 25, 1951.

3. Standardized working plan for local tests of seed source. Subcommittee on Geographic Source of Seed, Philip C. Wakeley, Chairman. Mimeographed. Southern Forest Experiment Station, New Orleans, La. Oct. 25, 1951.

4. Hereditary variation as the basis for selecting superior forest trees. Keith W. Dorman, Chairman, Subcommittee on Tree Selection and Breeding. Southeastern Forest Experiment Station, Station Paper No. 15. March 1952.

5. Directory of forest genetics activities in the South. Keith W. Dorman, Chairman, Subcommittee on Selection and Breeding. Southeastern Forest Experiment Station, Station Paper No. 17. March 1952.

6. Working plan for cooperative study of geographic sources of southern pine seed. Subcommittee on Geographic Source of Seed, Philip C. Wakeley, Chairman. Processed. Southern Forest Experiment Station, New Orleans, La. Sept. 12, 1952.

CONTENTS

	Page
Introduction	1
Suggested Projects in the Application of Genetics to the Collection of Seed for Planting	3
Suggested Projects in Geographic Source of Seed for Forest Planting	4
Objectives in the Improvement of Southern Forest Trees Through Selection and Breeding	5
Supporting Studies Needed in Techniques and Basic Aspects of Forest Genetics	7
Selection	7
Anatomical Studies	8
Breeding	8
Methods for Control of Flowering and Fruiting	10
Methods of Vegetative Propagation	11
Equipment for Tree Improvement Work	11

SUGGESTED PROJECTS IN THE GENETIC IMPROVEMENT OF SOUTHERN FOREST TREES

by

The Committee on Southern Forest Tree Improvement

INTRODUCTION

At the close of a South-wide conference on forest genetics held in January 1951, a standing committee representing State, federal, industrial, and educational forestry groups was appointed to foster and encourage tree improvement work in the South. This Committee on Southern Forest Tree Improvement has set up the following purposes to guide its work:

(1) To advise and assist those interested in the improvement of southern forest trees in arranging and conducting research and development programs.

(2) To provide a clearing house for forest tree improvement information.

(3) To provide for or assist in the coordination of a South-wide program of tree improvement research and development.

(4) To foster and encourage the advancement of knowledge of southern tree genetics.

The "how" and "what" of tree improvement work have been major concerns of the committee since its inception. The "how" has been approached by the preparation of guideline publications intended to summarize the best current recommendations or methodology in seed-source testing, selection of superior trees, progeny testing, and the application of genetics to seed collection. The guides published to date are listed inside the front cover.

The present publication attempts to tell the "what" of tree improvement research. It is directed to those who can help in a South-wide advance on the broad front of forest genetics and who want suggestions on what to do. For this purpose, the committee has compiled an inventory of the many studies that await attention.

The committee has not attempted to present a completely organized program with priorities and time schedules. The work selected by any

particular group necessarily depends on the local forest problem, the objective of the organization, and the money and skills available to it.

On the other hand, the committee does assist in coordination of programs to the extent feasible. Particular attention is called to the committee's "Directory of Forest Genetics Activities in the South," which should be used in conjunction with this list of needed projects. The directory tells who is doing what, and also lists the arboretum materials available throughout the South. Those interested in a given field of genetics research are encouraged to keep in touch with others who are shown by the directory to be working on the same species or problem.

The committee also serves as a clearing house for information through its semi-annual newsletter, its general meetings, its committee meetings, and its four subject-matter subcommittees on the following subjects:

Geographic source of seed
Genetic control of seed
Selection and breeding
Progeny testing

The committee is also glad to offer advice to individuals or groups as to the particular types of tree improvement work that will best meet their needs.

The remainder of this report is devoted to a list of projects or studies needed in the several major phases of southern forest tree improvement.

SUGGESTED PROJECTS IN THE APPLICATION OF GENETICS TO THE COLLECTION OF SEED FOR PLANTING

1. Definition of an acceptable tree suitable for seed production for different species, and possibly for specific uses.

2. Relation of average annual seed yield to age, site, stand condition, past cone-bearing history, etc., for different species, to show seed producing capacity of seed orchards.

3. Stimulation of seed production by means of fertilization, release, wounding, banding, and other treatments.

4. Research on the relation of drought, insects, and other factors to pollen, cone, and seed losses in southern pines.

5. Research on causes of low germination of apparently viable seed.

6. Seed-testing laboratory for service testing.

7. Techniques for mass storage of seed collected in abundant seed years.

8. Development of equipment for large-scale seed collection from standing trees.

9. Research on the inheritance of seed production.

SUGGESTED PROJECTS IN GEOGRAPHIC SOURCE OF SEED FOR FOREST PLANTING

1. Restricted tests of geographic source of seed within an agency's seed collection territory (for example, a State), as outlined in the committee's publication "Standardized Working Plan for Local Tests of Seed Source."

2. Participation in region-wide cooperative studies of seed source, such as those initiated under the sponsorship of the committee in 1951. See "Working Plan for Cooperative Study of Geographic Sources of Southern Pine Seed," prepared under the committee's sponsorship.

3. Basic studies of the phenological and physiological data associated with geographic seed source. Examples are dates of pollination, onset of growth, termination of growth, frost resistance, and response to day length of different geographic strains, both in seed source plantations and in native strains.

4. Relation of geographic seed source to disease resistance and to wood properties.

5. Studies of the relative effect of environment (climate, soil, etc.) and of heredity (local breeding populations, migration paths) as determinants of seed collection areas.

OBJECTIVES IN THE IMPROVEMENT OF SOUTHERN FOREST TREES THROUGH SELECTION AND BREEDING

1. Increased volume growth per acre in commercial species.

2. For particular purposes, develop strains of pine or hardwoods having wood characteristics desired, such as:

   a. High density and strength
   b. Low density and ease of working
   c. Desirable texture
   d. Long fibers
   e. Straight grain and low fibril angle
   f. Small knots
   g. Desirable sapwood-heartwood ratio
   h. Desirable content of extractives in the wood

3. Resistance to important diseases:

   a. Fusiform rust canker in slash and loblolly pine
   b. Brown-spot in longleaf pine
   c. Littleleaf in shortleaf and loblolly pine
   d. Fomes annosus root rot in redcedar, etc.
   e. Blister rust in white pine
   f. Oak wilt, heartrot, etc., in hardwoods

4. Resistance to insect pests:

   a. Bark beetles in all southern pines
   b. Nantucket pine tip moth in loblolly pine and shortleaf pine
   c. White pine weevil in white pine

5. Increased yields of high-quality naval stores products from slash and longleaf pine.

6. Tree varieties with high resistance to drought for planting on dry sites, especially longleaf pine and other species that grow naturally on such sites.

7. Strains of longleaf pine that make rapid initial height growth in the seedling stage.

8. Strains of forest trees that permit greater utilization of the stem. These strains in all important species may have shorter crowns, shorter branches, less stem taper, and accelerated natural pruning.

9. Hardwoods, such as yellow-poplar and white oak that do not have epicormic sprouts.

10. Varieties of yellow-poplar, maple, black cherry, walnut, sweetgum, etc., that have figured wood.

11. Black walnut that produces nuts of superior quality and at the same time high-quality wood in planted stands.

12. Sweetgum that has straight grain rather than interlocked grain, for ease in drying and working.

13. Redcedar that has high vigor, desirable characteristics for use as Christmas trees and other products.

14. Black locust with good form, high heartwood percent, and fast growth.

15. Virginia pine with straight stems, small stem taper, and better natural pruning ability.

16. White oak, red oak, ash, hickory, yellow-poplar, and other hardwoods that have high growth rate yet produce wood suitable for various products. This may require higher density, lower density, greater strength or other characteristics, depending upon use for products such as veneer, lumber, handles, etc.

17. Dense-crowned, rapid-growing firs, cedars, or other species that have attractive foliage, color, and other desirable characteristics for Christmas trees.

18. Polyploid or mutant forms of important hardwoods species that may have the optimum chromosomal complement for vigor, wood quality, and resistance to pests.

19. White pine that prunes itself well naturally.

20. Chestnut that is blight-resistant and that is a timber-type tree, suitable for forest planting sites.

SUPPORTING STUDIES NEEDED IN TECHNIQUES AND BASIC ASPECTS OF FOREST GENETICS

Selection

1. Develop techniques of selection:

   a. Determine the range of inherent variation within species with regard to tree quality for timber products (logs, poles, piling, ties, lumber, veneer, etc.), derived products (pulp, cellulose, lignin, essential oils, etc.), oleoresin, and edible fruit; also with regard to resistance to drought, insects, fungi, viruses, extremes of heat or cold, and mechanical damage from ice or snow. Determine standard deviation for each trait and the correlation between pairs of the more economically important traits.

   b. Conduct surveys for phenotypically superior trees and prepare catalogues to make them available to foresters and tree breeders.

   c. Determine intraspecific taxonomic variation in important species. This will require cooperation of taxonomists to re-analyze the status of species, varieties, forms, races, and strains.

   d. Incorporate knowledge obtained from studies in mode of inheritance into plans for selecting superior phenotypes in wild populations. This will require knowledge of the economic value of important characters and the degree of genetic control. The data will be used in writing specifications for phenotypically superior trees in surveys for breeding stock.

   e. Determine which methods of selection, such as the total score method, tandem method, or others used by plant and animal breeders, are suitable for use in breeding plans for forest trees.

2. Determine correlation between juvenile and adult characters or those of intermediate ages as a basis for selection in nursery beds or evaluation of hybrids at a very young age.

3. Determine the place of mass selection in silvicultural practices for major species. Results of these studies should guide selection of crop trees and seed trees when intermediate and final cuts are made. Criteria for judging the inherent value of standing trees will be needed.

4. Selection of phenotypes for specific purposes. It is probable that many aberrant forms of forest trees will be noted in surveys for phenotypically elite trees for forestry purposes. Some of the aberrant forms may have value as specimen trees or for landscaping. Others, especially mutants, may have value in cytological studies.

Anatomical Studies

1. Determine effect of variations in structural features (width of rings, proportions of springwood to summerwood, fiber length, and fibril angle in cell walls) on important properties of density, strength, shrinkage, and pulping properties of wood.

2. Develop practical methods for selecting trees with superior wood properties on the basis of the related anatomical features. This involves sorting out the purely environmental from the genetic influences on the above-named anatomical characters, so that inherently superior trees can be identified in the field.

Breeding

1. Learn mode of inheritance of various characters:

   a. Determine compatibilities for crossing within species of softwoods and hardwoods.

   b. Determine relative importance of chromosomal and cytoplasmic inheritance of morphological and physiological characters of economic importance.

   c. Determine Mendelian ratios for inheritance of vegetative vigor, tree form, crown width, pruning ability, resistance to pests, and other characters of economic importance. This

includes studies of dominance or recessiveness of important characters and studies of number of genes involved in inheritance of characters. The genetic correlation between pairs of traits should be determined. Breeding material for such studies may be obtained from studies of natural variation and surveys for phenotypically superior trees.

d. Determine incidence of hybrid vigor in crosses within and between important species.

e. For major species determine fertility of the seed and vigor of offspring after selfing. Self-incompatible species will require cross pollination; self-compatible species may be selfed or inbred. Selfing is a valuable technique for increasing genetic uniformity.

2. Develop methods for obtaining combinations of desirable characters in hybrids:

a. From the studies of mode of inheritance of characters determine effectiveness of cross-pollination and inbreeding to obtain combinations of valuable characters in the first generation.

b. Develop breeding plans for a series of crosses and back crosses suitable for use with forest trees. This will require modification of conventional methods used in breeding annual crops, fruit trees, and farm animals. With a knowledge of inheritance of characters in trees, it should be possible to plan a series of controlled crosses to combine valuable genes into superior gene complexes.

3. Cytological studies:

a. Determine chromosome number of tree species.

b. Determine incidence of naturally occurring polyploid individuals or races; also other types of mutants, such as amphidiploids and aneuploids. This can be done in conjunction with studies of intraspecific taxonomic variations.

c. Determine if chromosome pairing is normal in hybrids. This has a bearing on some types of sterility and is therefore important in breeding programs.

d. Determine optimum number of chromosomal sets for maximum vegetative vigor, particularly in hardwoods where some polyploids are more vigorous than are diploids. This also has

importance in breeding softwoods, where polyploids may be less vigorous than diploids and would have negative selection value.

e. Develop methods for inducing mutations, particularly polyploids, to develop new tree types and permit cross-breeding of plants that have different numbers of chromosomes so that they will produce fertile offspring.

4. Explore genus Pinus and genera of important hardwoods for breeding material:

a. Determine species mostly likely to be adapted to climatic conditions in the South.

b. Establish observation plots of selected introduced species to determine vigor, tree form, and resistance to pests under typical growing conditions in the South. These tests should be made in each climatic zone and physiographic region.

c. Analyze characteristics of important species of softwoods and hardwoods with the purpose of preparing breeding plans to obtain in hybrids superior combinations of traits such as vigor, tree form, and resistance to pests.

Methods for Control of Flowering and Fruiting

1. Develop methods for inducing flowering in very young trees to reduce the time required for controlled breeding several generations of trees. Techniques such as freezing, top grafting, artificial illumination, ringing, and strangulation may be tried. Also, selection of early flowering strains may be possible.

2. Perfect methods of stimulating flowering or fruiting in large trees, to aid in controlled breeding or in mass production of seed of selected trees and strains.

3. Develop methods of pruning and culture for mass production of seed in planted seed orchards. This might require methods of crown pruning to keep the trees small in size but capable of producing a large number of flowers. Such techniques would be useful in large-scale controlled breeding or in production of seed of superior strain.

4. Develop methods for controlled mass pollination in production of seed of superior strains. New techniques may be needed in seed orchard management to insure cross-pollination of certain strains to avoid possible undesirable effects of inbreeding. Control of pollen production would be an important aid in breeding monoecious plants because it would make emasculation unnecessary.

Methods of Vegetative Propagation

1. Develop methods of propagating--by grafts or cuttings--the important tree species. This includes grafting material from mature trees to seedling stocks and material from seedlings or young trees to branches of mature trees.

2. Investigate stock-scion relationships in forest trees to permit use of dwarfing or stimulating effects for special purposes in production of breeding stock, development of seed orchards, or for field planting. Field planting of grafted stock or cuttings may be feasible with figured strains of walnut, poplar, maple, and other species.

3. Determine to what extent ability of cuttings to root is genetically determined. If strongly controlled in certain species, rooting ability should be a character to consider in selection.

4. Perfect techniques for using vegetatively propagated material to estimate the genotype of selected phenotypes.

Equipment for Tree Improvement Work

1. Controlled breeding:

   a. Perfect more efficient equipment for collecting pollen, extracting pollen, bagging flowers, pollinating flowers, protecting cones from pests, and marking the flowers that have been pollinated.

   b. Develop new equipment or adapt existing equipment for climbing mature trees.

   c. Develop methods and equipment for storing and transporting pollen of all important genera.

2. Seed collection:

a. Develop equipment for collecting cones from mature trees.

b. Develop methods of seed extraction and seed cleaning suitable for small amounts of fruit.

The Committee on Southern Forest Tree Improvement

D. A. Anderson
T. E. Bercaw
Floyd M. Cossitt
Keith W. Dorman
G. I. Garin
George H. Hepting
C. M. Kaufman
P. T. Lannin, Jr.
E. B. Price
Philip C. Wakeley
E. G. Wiesehuegel
Carl E. Ostrom (Chairman)

Agriculture-Asheville

Membership of Subcommittees of the Committee on Southern Forest Tree Improvement

Geographic Source of Seed

P. C. Wakeley, chairman
D. A. Anderson
T. E. Bercaw
E. B. Price
J. R. Hamilton
R. M. Lindgren
N. W. Sentell

Genetic Control of Seed

F. M. Cossitt, chairman
G. I. Garin
P. T. Lannan
E. B. Price
R. A. Bonninghausen
E. Hinson
T. E. Maki
W. N. Palmer, Jr.

Selection and Breeding

Keith W. Dorman, chairman
D. A. Anderson
C. M. Kaufman
W. B. Baker
S. B. Chase
C. C. Doak
F. I. Righter
B. Zak
Bruce Zobel
E. S. Harrar
P. H. Harvey
S. S. Pauley
M. Y. Pillow
E. J. Schreiner

Progeny Testing

E. G. Wiesehuegel, chairman
G. H. Hepting
Keith Leasure
G. L. Schnur
L. T. Easley
G. W. Burton
W. H. Cummings
F. X. Schumacher
S. B. Chase
P. H. Harvey