CHAPTER 16

PROGRAM FOR IMPROVING SOUTHERN PINES

The effectiveness of forest genetics research in the southern pines must be evaluated on the basis of the gains in terms of wood volume growth and quality. A wide variety of agencies employing geneticists, tree breeders and foresters, plus highly trained men in related professional fields, has accumulated highly useful information. A coordinated program of work is needed to make the best use in general forestry of what is known and to generate further research results. Creating genetically better trees requires a direct, concerted, and sustained effort toward a single goal and is in contrast to generalized research programs, where choice of work is more or less at random within a broad field.

Efficient production of forest products is needed to meet increased demands. As the population grows, forest land may be acquired for other uses such as residential areas, airports, highways, pipelines, electricity transmission lines, recreational areas, hydroelectric projects, wildlife management areas, natural areas, wilderness, or farming (fig. 197).

Discussion of genetic and breeding principles and inheritance of traits tends to oversimplify the problem of creating an improved crop, because it is necessary to progress from one thought to another on a surface plane. In practice, the complex of subjects is shaped more like a pyramid, and the factors involved all interact all the time. The sides are composed of genetics, plant breeding, species with their particular combination of traits, and the cultural requirements of the crop. As can be appreciated, each of the individual sides is an amazing complex of variables—many must be understood and manipulated by the breeder to reach the point of the pyramid represented by an improved strain of trees to improve yield of forest land.

For greatest efficiency in breeding, the pyramid should be a solid structure from bottom to top, with the right kind and amount of information. In practice, as demonstrated by successful work with numerous crops, certain parts of the structure may be only a framework consisting of trends and indications shored up by the intuition of the crop breeder.

In the South, the Southern Forest Tree Improvement Committee (Kaufman 1971) has been a dominant force in stimulating and guiding research, promoting creative breeding, and getting improved seed into use. A recent example of their leadership is the development of a list by Dinus *et al.* (1973) of suggestions about problem areas in creative breeding, seed production, and techniques. The list is as follows:

	Mean priority ranking
Advanced-generation-pine breeding strategies	4.1
Hardwood genetics and breeding	3.4
Forest gene resource conservation	4.0
Fusiform rust resistance breeding	3.7
Juvenile/mature correlations	4.0
Reproductive physiology	3.2
Pine pollen management	3.0
Cone and seed insect control	4.6
Cone and seed harvesting methods	3.8

The Southern Forest Tree Improvement Committee has given force and direction to preparation of various publications in tree breeding and forest genetics research. Highly specific objectives and priorities for research may seem to be desirable, but these are not feasible for the vast southern pine region because different tree species occur at various geographic locations and the legal authority of agencies to do research and development varies, as do the size of their budgets, the capabilities of their employees, and the types of research facilities, such as laboratory equipment and field planting areas. Detailed plans of work can nevertheless be prepared for smaller geographic areas and individual organizations such as States, industrial companies, and State and Federal research organizations. This has been done.

If genetics and tree breeding research are to improve wood yields of southern pine forests, strains for and techniques applicable to planted stands and, what is more important, to natural stands must be developed. Natural stands far exceed planted stands in area. Methods are needed for genetic improvement of natural stands through use of greatly improved techniques of natural regeneration and improvement cuts.

Improving the yield of pine forests will require a program which, reduced to the basic terms, consists of (1) research and (2) land management or administration. Research must generate principles, data, ideas, techniques, and improved tree strains. Administration must mass-produce improved strains, or stimulate their production, and get improved trees planted or improved silvicultural methods applied.

The research effort may be divided into broad subject-matter fields such as (1) genetics, (2) applied genetics, (3) tree breeding, and (4) applied tree breeding. These fields of work differ in objective, method of study, and basis on which research results or accomplishments are evaluated. It is true, of course, that in rare instances principles, ideas, or research data may skip certain subjects in progressing from genetics to practice or applied breeding. Also, there may be a gray or twilight zone between the broad subjects for work on isolated studies or technical fields, but these examples should not be used to obscure the importance of recognizing the four distinct, major fields of work.

The distinction between the objectives of each of the four fields of work must be kept clearly in mind in discussions of research with the general public. Many people assume that genetics research concentrates directly on creating improved trees, but this is not the case. Genetics research and tree breeding in separate projects can be doing vastly different and highly essential work but, in the eyes of the public, appear to be unnecessary duplication of effort. Furthermore, genetics, as a subject, has become so highly complex and specialized that many geneticists give little recognition to problems in creative plant or animal breeding.

Precise statements of objectives are highly essential in research administration in order to evaluate accomplishments as well as to plan new work. This is important for the southern pine region because of the diversity of research projects and the necessity to achieve proper balance in the regional program to reach the goals.

GENETICS, APPLIED GENETICS, TREE BREEDING, AND APPLIED TREE BREEDING

The most difficult part of developing projects and research programs is in making the step from the first three groups to the last—applied tree breeding in order to create new strains. Making this step is the old and familiar problem: getting results into practice. For example, use of seed from current southern pine seed orchards is expected to increase wood yields 10 to 20 percent. Results from a large amount of genetics and tree breeding research indicate that much higher gains are possible. Thus, the important problem in the South, it seems, is to get more research results into practice by creating strains with high yields of wood.

Utilizing research data and techniques has been a problem in breeding plants other than trees. Hybrid vigor was known in corn breeding many years before it was used to create high-yielding strains; the genetics of the determinate growth habit of tomato was known long before the knowledge was applied by breeders, thus revolutionizing tomato-raising methods. How many years will pass before we double the growth of southern pines on a southwide basis?

MAJOR SUBJECTS IN BREEDING

The major field of work in each of the four major subjects listed above is indicated by the title, but the exact boundaries are obscure and certain study objectives and results may apply to more than one subject. To illustrate the relationship among the four research fields, investigation of mutations and metrical traits will be considered. Both are important in genetics *per se*, but metrical traits are important in creative pine breeding, while mutations are not. A brief comparison of the kinds of studies for mutation research is as follows:

1. Genetics: Kind of mutations, polyploids or haploids; frequency of mutations and ploidy; and importance of mutation in evolution of plants and animals.
2. Applied genetics: Relation of mutation and ploidy to economic value in improving yield and quality or in creating entirely new individuals; development of techniques of controlling mutations and ploidy in plants and animals.
3. Forest genetics: Kind and frequency of mutations and ploidy in forest trees; chromosomal aberrations in tree species hybrids; techniques for controlling mutations and ploidy in trees; and mutations in taxonomy of softwoods and hardwoods.
4. Applied tree breeding: Surveys to select desirable mutations in each important species; application of techniques to create mutations with special characteristics in a particular tree species; incorporation of mutant trees in breeding systems such as recurrent selection and backcrossing; and comparison of the effectiveness of mutagenesis with alternative breeding methods to create specific new strains.

A comparison of four fields of research in the subject of matrical or continuous traits is as follows:

1. Genetics: Kind of traits showing continuous variation and development of techniques for estimating heritability of traits in plants and animals.
2. Applied genetics: Relationship of metrical traits to economic value; development of breeding systems involving metrical traits; and relationship among traits in improving plants and animals.
3. Forest genetics: Kind and importance of metrical traits; inheritance and heritability estimates by trait; correlations among traits; and development of breeding systems for hardwood and softwood trees.
4. Applied tree breeding: Controlled crossing in field tests to create trees with excellent combinations of traits; field comparisons of breeding systems to create trees with improved metrical traits

combined with higher than average levels of vigor; estimates of costs and benefits of various breeding systems by species and geographic location to permit action agencies to choose the best methods for their use.

GENETICS VERSUS PLANT BREEDING

It is difficult at times to relate breeding methods to genetic principles because they are not considered together in text and reference books. Genetics texts may cover only mutations, dominance, multiple factors, crossing over, linkage and other subjects applying to both plants and animals. To fill the need for reference works, texts devoted entirely to plant and animal breeding concentrate on genetics from the standpoint of *creating* new and better plants and animals, in contrast to *investigation* of relationships, which is the field of genetics. Discussion of the same principle or subject might be drastically different in genetics versus breeding texts because of the difference in importance and the manner in which data are used in *creating* new plants. Thus, it is possible to obtain much information on the subject of genetics by reading genetics texts but very little in the subject of breeding.

Lack of competence in breeding techniques and knowledge about particular species may cause geneticists to project results of limited studies further than warranted as an improvement or aid in breeding. Usually this enthusiasm is unintentional and is a result of trying to apply general theory to specific breeding problems. For certain specific combinations of geographic region, tree species, and trait, the advantages of tree improvement methods, such as introduction of new species, mutagenesis, and species hybridization, have been somewhat oversold, although these methods, in general, have merit.

One of the best characterizations of the plant breeder's work was prepared by Burton (1966) for a plant breeding symposium. He gave the six words that should describe a plant breeder's activity as follows:

Variate ↔ Intermate
Isolate → Intermate
Evaluate → Intermate
Multiplicate
Disseminate

As used here, the word *intermate* describes recurrent selection. Burton points out that these words are all verbs—all action words.

Obviously, genetics is basic to creative breeding. Justification of expenditures for research is based on this relationship. However, only certain subjects are directly useful in breeding, and many have only very indirect or vaguely identifiable relationships to breeding problems. We should not allow ourselves to be trapped by the idea that unlimited genetics research will automatically solve all tree breeding problems.

IMPROVING YIELDS OF SOUTHERN PINE FORESTS

Success in increasing wood yields will depend on a good balance of effort to acquire fundamental data about genetics and scientific applied breeding and to apply the data in creative breeding of new varieties, place seed stocks into seed orchards, and produce seedlings to plant—in other words, a desirable balance among and sequence of major research and administrative jobs.

Table 8 shows the sequence from theory to practice, the objective of each subject, and the more important jobs needed to attain the objective. It does not give details by species, trait, geographic location, or subject as they would be treated in research studies, but these have been discussed in earlier chapters or in those to follow.

A coordinated plan for southern pine breeding need not conflict very strongly with the principle of a certain amount of freedom in choosing research problems. A portion of the research effort should be directed toward development of new ideas and following promising leads. Also, a plan is helpful in identifying research areas where fundamental work on principles will contribute significant results to the program and protect the researcher from pressure to work on low-priority basic subjects.

The most difficult step in tree breeding is from the research subjects in b–1 through b–6 to those designated c–1 through c–3. For example, it has been rather simple to demonstrate inherent differences among races and individual trees and the relationship between traits. It has not been simple to utilize the information to establish seed orchards and to produce stands of trees combining the best racial and individual traits—the best overall combination of traits. This step is needed to enable landowners to estimate costs of tree breeding and seed orchard projects in relation to returns in the form of improved wood yields and quality. Research of this kind makes use of data from investigations as the basis for projecting ideas in physically creating real trees and stands of trees. This is a very large step forward. Also, it is the research area in which theory and data meet the world of business, or forest land management, and the controls imposed by costs and returns.

Now that a large amount of excellent research data has been accumulated for the southern pines, the urgent need is to make intensive use of it in applied research to improve wood yields and quality. Plot studies indicate that wood yields from use of seed orchard seed are not yet as high as they should be and could be.

Table 8.—*The sequence from theory to practice in a coordinated research and tree improvement program*

Subject	Major objective		Technical subject and administrative jobs required for each species and geographic location
I. Theoretical plant breeding	A. Develop forest tree breeding theory	a–1.	Breeding cross-pollinated crops: mass selection, backcrossing, hybridization, recurrent selection or creation of synthetic varieties
		a–2.	Introduction of new species
		a–3.	Mutagenesis, polyploidy, and haploidy
		a–4.	Techniques
II. Forest genetics and tree breeding research	B. Test tree breeding theory	b–1.	Phenotypic variation in traits
		b–2.	Inheritance of traits and combinations of traits
		b–3.	Characteristics of southern pine species hybrids
		b–4.	Performance of introduced species
		b–5.	Number and kind of mutations
		b–6.	Relationship among traits (positive or negative correlation, no correlation)
	C. Conduct creative breeding	c–1.	Crosses of plus trees to improve a trait or combination of traits
		c–2.	Crosses of species by using plus trees and the best race to improve combination of traits
		c–3.	Tests of races to select for use in each geographic location
III. Applied tree breeding	D. Produce stock for seed orchards	d–1.	Select clonal stock from stands or progeny tests
		d–2.	Breeding to create clones for seed orchard use
		d–3.	Develop methods of improving natural stands
IV. Commercial seed production	E. Produce genetically better seed and seedlings	e–1.	Establishment of commercial seed orchards by forest industry and State and Federal agencies
V. Commercial forestry	F. Grow improved trees	f–1.	Planting or direct seeding by landowners