Need for Total-Tree Concept

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After listening to a series of summaries as to where we stand on various phases of the Scuthwide program, it seems any man would be very ungrateful to talk about needs. But we can't stop now. The job isn't done for the pine seed orchard program. It has hardly started for hardwood species and minor pine species.

We have finally entered an age of tree breeding in Southern forestry. The huge pine seed orchard programs are one of the few truly huge and regional Southwide programs in modern times.

The job of producing tree seedlings of improved strains is a big one. It will take time, but it can be done. Other large jobs have been done; you developed a planting program that is bringing thousands of acres into production. You are well underway on fire protection. If you don't believe this, just examine the old photographs taken in Florida woodlands by naval stores researchers in the 1920's. The background scenes are pretty grim. You built a great Southern pulp and paper industry. You not only built it, but you did it in such a way that there are more forest lands and trees now than when you started.

There is a need in our Southwide program for continuing emphasis on creative tree breeding. This will bring into production the improved strains we need. We don't want to lose sight of our main goal amid strong and productive research on techniques and principles. This is not to say we need less research on methods, but rather to say we need more on creative aspects. As interesting as it is, methods research is not the end point of creative breeding. We have to create the trees--whole trees, the total tree-- not just traits. Just last month in Washington, the Chief of the U. S. Forest Service told the Forest Industries Cummittee on Timber Valuation and Taxation. that new projections of demands indicate that we will have to double the pulpwood cut between now and 1985 to keep pace with expanding markets. This is about 18 years from now. Eighteen 'years ago we were about ready to organize the Committee on Southern Forest Tree Improvement. A lot of trees are going to be grown in the immediate future.

We want our Southwide program to be known not only for the excellence of its various parts but for the excellent creativeness and productivity of the program as a whole.

We need to maintain the integrity of the regional program. This gathering in Knoxville today and tomorrow is a conference on forest tree improvement. The group sponsoring it is the Committee on Southern Forest Tree Improvement. We meet to discuss improving forest trees, not just forest genetics, not just promising leads, not just improved techniques, but the sum total of all our efforts, improved trees, the total tree.

Before mentioning some of our needs in the future, we might comment on some of the accomplishments of the past. One thing that stands out in a review of accomplishments since 1953 is the contribution of industry to the research and action program. The list of cooperators in research is like a roll call of forest industry. The number of forest industries represented at conferences like this one is equally impressive.

This is a particularly good time to take a brief accounting of where our program has taken us over recent years, and to take a quick look at some jobs ahead. The Committee on Southern Forest Tree Improvement has sponsored a survey of forest genetics and forest tree improvement research in the South and Southeast. Although a report of this kind is out of date almost before it is completed, the 90-page booklet does give a pretty good picture of research. Copies are available at the Southeastern and Southern Forest Experiment Stations.

Another report important in evaluating progress is an extensive summary of the genetics of southern pine species, both major and minor. I've nearly completed the first draft of this paper, and after abstracting over 900 papers that contained research results, I can assure you that there may be things Southern researchers haven't done, but failure to

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publish articles certainly is not one of them.

Southern research has made important progress in all broad fields of tree improvement. We tested many foreign species, particularly softwoods. In general, this method of getting improved strains isn't very promising, although it may be a factor locally. Racial variation studies with pines have been numerous and productive, but it looks like the movement of seed long distances is not feasible in coastal regions. In certain local areas inland, it may be more promising. Racial selection studies have pointed out forcefully how great losses in growth could be from using the wrong race of seed. Species hybridization has been carried out at a few locations and there seem good opportunities for considerable genetic gain by combining the best traits of the best individual trees of the best races of the best species for specific localities. Selection within species has received the lion's share of attention, and the estimates of gains possible seem to be increasing rather than diminishing. This gives added impetus to the seed orchard programs. Also, it points out opportunities for substantial improvement through really intensive breeding programs with readily available local trees. This approach to creative tree breeding has great opportunities for the future.

School Problems

There is a need for continuing the strong emphasis on creative tree breeding in teaching and research at educational institutions. Our Southern schools should give great attention to this field of study, as well as to the field of forest genetics. Regardless of which agency or group does applied tree breeding—the Federal government, State forestry agencies, private industry-- the men doing it should be well trained. They won't be if the schools don't train them, and the schools won't give them this training unless first-class men are available as t ea chers or instructors. Present teachers have to teach future teachers who can in turn teach students.

Without good academic training facilities, recognition of the importance of tree breeding, and good job opportunities, creative tree breeding activities will not attract the best minds and the best men. This means that the final step in all forest tree breeding work --that step between research and practice, or between the printed word and the living tree-- will have to be taken by the next best, the poorly prepared or the poorly trained.

Tree breeders aren't made in a day. They must be well trained in genetics, and in addition they must know the important factors in utilization of the crop and the culture of the plants with which they work. The necessity for being highly trained or well informed in three broad subject-matter fields is the main reason that creative tree breeding is more complex than is forest genetics alone.

Speaking of plant breeding in general, Professor Caldwell of Purdue University described the probl em as follows to the International Crop Improvement Association at one of their annual meetings.

> "Agricultural development is inherently the ultimate objective of our agricultural institutions. It must not become the neglected stepchild of these institutions. Work on development must be staffed with first-class, creative talent, no less than research work, unless we are to have second-rote work in development. Development work is often much more costly than the research from which it arises, both in industry and in agriculture. While agriculture must, and does, support the great new expansion in basic research, it is beyond comprehension that it would tolerate a simultaneous neglect of the development work that would translate the new research findings into agricultural achievement."

Trained tree breeders and forest geneticists continue to be in short supply. There is a job here for everyone to increase enrollment in these fields of work.

Southern schools have been doing an admirable job of coordinating but still keeping some degree of distinction between three quite large but different fields of work: teaching, research, and large-scale applied breeding. This is truly a great accomplishment achieved in a short time, and Southern forest industry will benefit greatly.

Silvicultural Problems

Industry can help the overall Southwide program by devising methods of getting strains into use. It takes 10 or more years of breeding and testing to get certain strains of annual crops into production. A schedule of this length is nearly impossible with trees and we should admit it. At the same time, the tree breeder can't ask others to take great chances on his products. There must be a middle ground somewhere. Perhaps the possibility of using mixtures of wild stock and improved strains or mixtures of different improved strains should be investigated. If certain trees do not keep pace with the group they will fall out. They will do this regardless of their origin. Pure plantations are easy to handle silviculturally, but perhaps there are advantages in other types of planting. We have changed our ideas about spacing, intermediate cuts, and rotation lengths, so perhaps we can do it in regard to mixtures. There are various ways of mixing strains. Also, mixtures could be varied from year to year in proportions according to performances of strains planted at earlier periods.

Industry can emphasize creative breeding. We can have scholarships, awards, and other types of

recognitions similar to those given now for research. Because of the high values involved, industry publicity men should have a field day with this subject. We have been getting good mileage out of some of the seed orchard programs.

Creative breeding is too important to be left to chance. It requires too many operations, too many jobs in sequence to happen spontaneously. Therefore, we have to make special efforts to achieve it. Industry can support the efforts to bring it about. This they have done and are doing, but we don't want the effort to slacken pace. They should keep the pressure on researchers and educators.

There are strong forces supporting research in methods. Prestige, recognition by colleagues, and good salaries are strong incentives. This is good. The spirit of publish or perish that is abroad in the land puts great pressure on researchers. The best way to obtain something to publish is to make a study. But studies don't mean new trees or total trees, so something in addition is needed. There is a difference between a bad thing and misuse of a good thing. Research is not bad, but unless considerable effort is expended in creative breeding we.are being unrealistic about a proper division of our total effort.

Research Problems

In our broad Southwide research program, the process of creating strains and getting them into production should be under constant examination to see where there may be opportunities for speeding up the job. For example, our progeny testing methods for seed orchard clones are expensive, time consuming, and lengthy. If we could demonstrate there was a high correlation between the performance of the grafted trees and their sexual progeny a great savings would be realized because we wouldn't have to conduct progeny tests to verify performance. Perhaps we'll find the correlation may be high for certain traits but not for others. Even so, this may be very important because the traits we do have to test for may be those that require only a few progeny or a few years' time.

Research is generally investigative, whereas tree breeding is creative. One is not a substitute for the other. There has to be a conscious effort to keep in mind the problems and goals of tree breeders and take advantage of every opportunity to move ahead. This helps in choice of research problems and interpretation of results. In other words we have to be tree breeding conscious to make progress. The man who saw a giraffe for the first time and then commented authoritatively that there ain't no such animal was not a trained animal or plant breeder. We have done little better in tree breeding until recently. We looked at fast-growing, well-formed , disease-free trees and said it can't be true. We have said this thing we see can't be genetic so it must be environmental. It was not until we questioned whether or not the effects were environmentally caused that we found out that the trees were correct and we foresters weren't.

It seems that creative tree breeding is becoming one vast problem of sampling, comparing, correlating, and predicting. These are also fields in which statistical methods are particularly useful. We should utilize them fully, not only in research studies but also in creative breeding. Relationships are important, but absolute values are often of greater importance to the tree breeder. In the report of a large study of geographic variation, a discussion of relationships covers 67 pages. The paper contained 68 pages and on page 68 are given the absolute values for the traits studied. There is constant need to scrutinize our study designs to make them produce the biological information we need in the shortest possible period of time. We have many data now on which to work in improving techniques.

In any broad field of biology there is always a need for work on fundamentals and principles. Tree breeding and forest genetics are not exceptions. However, there are some differences of opinion among researchers as to what constitutes good work in these fields.

We should not be misled into thinking that research in fundamental principles is characterized only by the fact that the results may not be useful. Other standards are more important. For one, great imagination must be demonstrated in defining the problem and in developing a solution. For another, the possible results must show great promise for yielding information on principles or procedures that will have far-reaching effects. And last, highly complicated instruments must often be developed and used.

The second characteristic of good research, that it show great promise, is very important. One research administrator has remarked that great imagination should be used to develop a problem and a method for solution, but that when the researcher comes to the justification section of his study plan or project proposal, he should face up to the cold, hard facts of life and ask himself just how important the work really is. Does it really have great promise of contributing to our knowledge of broad and useful principles. If it doesn't, probably the study isn't very fundamental.

There is a great need, I think, to mount a massive attack on the genetics of tree growth rate. In spite of all that has been said and written about breeding fast-growing strains of trees, we really haven't charged headlong into the problem. What are the fundamentals of variation and inheritance of growth? What are the ways in which breed-

ers can influence or increase growth? Will we know more about these factors 20 years from now than at present? Growth is certainly not an easy subject to investigate, but this doesn't decrease its importance. Good estimates of growth performance require extensive replications in time and space. Both of these are very hard things to come by in this speed-up age. But growth studies are so important we will have to make them.

It has always seemed to me that plant physiologists and geneticists should work very closely together. Both work at the very origin of life processes and a combination of their skills should create wonders in creative breeding.

We should not be misled into thinking that if we understand the general principle of how plants work we can manipulate the processes at will. Something more is required. We have to know at what key points we can influence the process by the means at hand. James Bonner, in an article entitled "The Upper Limit of Crop Yield," used this approach. He said, "We have seen that plant efficiencies are in general limited, under high light intensities, by the CO2 concentration of air. Might it be possible to breed plants for leaves in which there would be increased conductivity of CO_2, in order to lessen diffusion resistance to CO_2 or to shorten diffusion paths?" After describing the limitations of chloroplasts, he suggested that their structure might be altered. He said, "Such a modulating chloroplast should be able to operate at an efficiency equal to the quantum efficiency of photosynthesis over all light intensities from zero to that of full sunlight. Might it not be possible to breed plants for such an improved and more sophisticated type of chloroplast structure? It seems today a difficult problem. Perhaps it is an insoluble one. But it is certainly a goal worth consideration. The fruits would be large indeed." It seems to me that here is a fundamental problem of sufficient importance and complexity to attract the best research minds in the South.

A good research program has a balance between studies in which yields are low but certain and those in which yields may be high but uncertain. Increasing photosynthetic efficiency through breeding might fall in the latter group.

We need all the information we can get on heritability of traits in the classic sense. But, we need to know about inheritance of individual traits in the tree as a whole. 'As geneticists have pointed out, the environmental component in heritability estimates is of great importance. However, when we review all environmental factors over the southern pine region geographically and the time period required for a rotation, the job of testing all these environmental factors becomes nearly impossible. Creating new kinds or strains of trees contributes greatly to our knowledge of inheritance of specific traits and combinations of traits. Thus, there is a strong research flavor to field studies involving growth of trees resulting from crossing for specific purposes. So, in regard to the question of which should come first, research or applied breeding, it is impossible to tell the cart from the horse.

We are approaching the time in our Southwide program when we should consider progress and problems in terms of species. In genetics research, the subject investigated often is of prime importance. The species used and the geographic location of samples are secondary. We accumulate a large body of information on a subject, but with widely varying species and at different geographic lloc ns. The tree breeder, on the other hand, has to work with a wide variety of subjects but with only one or a few species and at one geographic location. In other words, he doesn't breed trees in general over a wide area, he is face with a species and its particular problems at a geographic point. Perhaps sometime we should consider holding workshops on breeding for each major tree species. This would help focus attention on pro. gress and problems with the tree right on the ground where the problems occur and work is in progress.

The other day I was reading an account of how the dwarf, high-yielding strains of wheat were developed by plant breeders at Washington State University. The research that has been done and the information accumulated about wheat is so large that it is almost impossible to visualize. Yet, when the particular crop-breeding problem came up with the dwarf types, a lot of work had to be on a trial-and-error basis, using educated guesses by experienced plant breeders. Even then it required nearly 10 generations to develop and test the new strain. The point here is that creative plant breeding can hardly be reduced to a rule-of-thumb process. There has to be consistent effort applied along several different lines in the hope that some one of them will produce the desired result. We shouldn't wait to start breeding until we think we may have all the answers. This may never be, as breeders, working with plants or animals which are much easier to work with than trees, are finding out. Science can contribute greatly, but art is still a requirement in creative breeding.

Conclusion

These are only a few of the problems of importance to the Southwide program, but I think they are major ones. Furthermore, work has been done on all of these and this is good. The greatest need is to broaden current efforts and make them more meaningful. Our Southwide program is very broad. Constant effort is required to keep it under review, and stress the more important of many important problems that apply specifically to the creative breeding work.