POSSIBILITIES AND LIMITATIONS IN TREE BREEDING

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First of all, I would like to explain that the title of this paper was not coined by me. Had it been, I should certainly have avoided use of the ambiguous and misleading term "tree breeding". My antipathy to this term is, I believe, justified, on the ground that it has suffered such wide misuse, both in the literature and in general conversation, that I am not altogether sure what its present meaning is.

The principal source of confusion derives from the fact that the term "tree breeding" has a sort of mesmeric connotation to some people, implying a degree of genetic control and predictablility of result that one associates with such terms as "corn breeding" or "wheat breeding". Misinformed persons may thus understandably conclude that "super--hybrids" are the immediate and sole objective of efforts designed to apply genetic priciples in forestry. A much more realistic substitute for "tree breeding", it seems to me, is the term "trees improvement", as wisely incorporated by this committee in its name. The special virtue of this term, as I interpret it, lies in the nonrestrictive implication that improvement in tree phenotypes may be accomplished by both genetical and environmental manipulation.

In considering the possibilities in tree improvement, we may gain some satisfaction from the realization that, theoretically, there are essentially no limitations to such possibilities from the genetic viewpoint. If the genetic basis of the theory of evolution is correct, we should be able to start with a pine tree (or perhaps two, to avoid the possibility of a self-sterility barrier at the outset), and from this comparatively meager supply of genes not only develop genetically elite forms of all of the species and races of Pinus, extinct and extant, but tolerable oaks, ashes, and even buttercups and daisies as well.

Although such a program would be theoretically possible, there seems to be little likelihood that the Committee on Southern Forest Tree improvement or even the Forest Genetics Research Foundation would demonstrate much interest in the encouragement or fostering of such a project. The obvious reasons, of course, are simply that such a venture would doubtless require the expenditure of several billions of dollars over a period of several hundreds of thousands of years. In short, it would be an impractical undertaking, the profitable results of which would be far outweighed by their cost.

The initial question to be resolved before undertaking a tree improvement program is, thus, an economic one: will the results obtained outweigh the costs involved? Unfortunately at the present time this is a question that frequently cannot be answered by the forest economist alone nor by the geneticist alone, and in most cases even their collaborative efforts are almost certain to result in only a rough appraisal. The primary reason rests on the fact that our fundamental

genetic knowledge of forest trees is so deficient that cost estimates for the attainment of a specified objective must be based almost exclusively on tentative hypotheses.

In the intensive breeding of such crops as corn and wheat, the cost in terms of time and money required for the development of a new strain or race adapted to a new environment or resistant to a new disease can be estimated with reasonable accuracy because of the great fund of basic information available to breeders of these plants. Much of such information was gained by trial and error improvement efforts; but the great bulk was doubtless gained by a disinterested search for facts, regardless of whether these facts had immediate utilitarian value or not.

There is always a general tendency in any new field of scientific inquiry to put the practical cart before the fundamental horse. Whether this is indeed a real danger to the sound development of any science is frequently a question for debate in academic circles. Certainly it would be most desirable to confine the research activities in the field of forest genetics to fundamental investigations for a few decades. On the basis of fifty or sixty years' intensive study of the southern pines, our successors would undoubtedly be in a much more favorable position to design specific plans for their improvement. The fact is, however, that the world is not overpopulated with altruistic millionaires; and, in consequence, fundamental and applied research are frequently forced to share the same bed. In spite of the fact that to some purists such a symbiotic relationship is in poor scholarly taste, it is doubtless here to stay.

In recognition of the present deficiences in our fundamental knowledge of most trees and the consequent inadequacy of our ability to improve them genetically, the only necessary restriction in the field of improvement research would appear to be that we proceed with reasonable caution and common sense.

Fortunately the situation at the present time is most favorable for the development of forest genetics and its applications in forestry here in the South, where the need for extensive planting is immediately necessary. Under such conditions the extensive genetic improvement of planting stock can be carried on at small additional cost, and economic considerations may thus be essentially ignored.

Certainly of first priority in the prosecution of a forest tree improvement program for any region is an assessment of the wild stock for the purpose of isolating desirable wild genes or gene combinations in stands or individuals. Such investigations on a geographic basis as discussed by Mr. Wakeley are now under way in the South, and various other workers have reported the initiation of efforts to select and progeny test desired phenotypes on a local basis.

Such extensive improvement efforts, in my estimation, represent one of the most important activities of the Committee on Southern Forest Tree Improvement. If at the end of the next fifty years all of the forest nursery stock produced in the South is grown from seed derived from wild trees of proved genetic superiority, I think this Committee will have served its purpose with notable success.

There is, however, good reason to believe that within fifty years the utilization of the best wild seed available in the southern pine region will be looked upon as an antiquated practice. Surely by that time the logical procedure of combining superior genotypes within a species by controlled crossing will have long since occurred. By the utilization of the seed orchard technique as a means of making such crossings, there is good reason to believe that not only can the genetic quality of the seed be improved over that of the best wild stock, but the cost of production may actually be reduced through increased facility of collection.

Thus far my remarks have been confined to extensive tree improvement methods only. I can envisage no limitation, economic or otherwise, that would discourage the continued prosecution of such extensive improvement activities.

There is, of course, perfectly valid criticism that such extensive methods are incapable of tree improvement to a high degree of efficiency. There is sound ground for inference that moderate inbreeding designed to fix valuable traits may be utilized to the same advantage in some tree species as in various agricultural crops. Inter- and intraspecific hybridization accompanied by back-crossing and selection may doubtless yield valuable new combinations of characters especially suited for special localities or uses. Valuable F_1 inter- or intraspecific crosses may be found which will not only satisfy the demands of "hybrid vigor" enthusiasts but will also yield an F2 with sufficiently large percentages of superior forms to justify natural seeding of the area by the original F1 crop.

Although such intensive breeding techniques hold great promise for the future of tree improvement here in the South and elsehwere, I feel that efforts to promote them vigorously at the present time and in the present inadequate state of our knowledge would be unwise.

I have often thought it in many ways odd that most of the current interest and enthusiasm in forest genetics is still associated an large measure with the idea that the primary practical application of this science is for, the purpose of creating new tree "master races" and "super-hybrids" for planting. Such tendencies to an extravagance of emphasis and expression are no doubt justifiable as a means of rallying recognition and gaining financial support in the initial stages of the new application of a science. One unfortunate difficulty, however, is that such ideas often persist, and when eradicated the misled individual may well question the validity of any result less spectacular or world-shaking than he has been led to expect.

What we might refer to as the "super-hybrid" concept of forest genetics is not the exclusive property of misi nformed non-foresters, but is held by a very considerable number of foresters as well. The real tragedy in such cases lies in the fact that many foresters seem to be of the opinion that forest geneticists are concerned in their work with some obscure ill-defined medium quite unrelated to the normal functions of growth and development in forest trees.

This unfortunate state of affairs is probably in large part traceable to the continued persistence of the mid-nineteenth century silvicultural dogma that all variation of any consequence in forest trees is environmentally induced. One natural and regrettable consequence of this concept of genetic uniformity is that the bulk of intraspecific variability detectable in the forest is still confidently attributed to environmental differences. And efforts are still made to rationalize silvicultural systems of management based on a study and manipulation of the environment alone.

I do not wish to imply that the silvicultural manipulation of the forest environment is undesirable. Indeed, from the practical point of view in forest management, such manipulation of the environment is the most direct, and will doubtless continue rightfully to be the most important, method of influencing changes in the phenotypes of forest trees. Silviculturists must, however, eventually discard the complacent assumption that an intimate knowledge of the physical properties of the soil or the microclimate will in itself, independently, supply the answers to the best method of growing genetically complex populations of forest trees. If logical solutions to the numerous problems confronting the silviculturist are to be solved rationally, research methods must of necessity be adopted that will in some reasonable manner evaluate results, in terms of both the environment and the particular genotypes concerned.

Preoccupation with the "super-hybrid" complex in our thought processes seems to have dulled our realization of the fact that the silviculturist, in the practice of his art, manipulates the environment chiefly by the use of axe or saw, and thus through thinnings, improvement cuttings, etc. continuously exerts a direct and controlling influence on the genetic composition of the stand. To the credit of the silviculturists, the dysgenic effects of "high-grading" practices have long been recognized, and conscious effort has been made to eliminate them. We are still, however, in a state of almost complete ignorance on matters concerned with the problems of mass (or silvicultural) selection as practiced under self-reproducing silvicultural systems.

When we realize that the great majority of the forests of this country are at present, and will doubtless long continue to be, managed under systems of self-reproduction, we must make the altogether reasonable inference that if their genetic quality is to be improved, or at least maintained, we must eventually come to recognize the necessity of learning considerably more about their hereditary characteristics than we know now. It is my feeling that one of the principal and unavoidable responsibilties of forest genetics is to contribute to this knowledge. I think it is a matter of little consequence whether such knowledge is labeled "genetical" of "silvical", or whether it is accumulated by self-styled "forest geneticists" or "silviculturists".

In summary, although the theoretical possibilities in forest tree improvement from the genetic standpoint are essentially unlimited, we must recognize that the practical possibilities of improvement are at present gravely circumscribed by a horizon of ignorance. For this reason, the advisability of confining early improvement efforts to

extensive measures, rather than to intensive tree breeding schemes, should be emphasized. With the accumulation of fundamental genetic data from progeny tests and other studies, efforts may be logically directed to the development of intensive improvement methods.

Finally, with the eventual dissolution of the environmentalist doctrine in silviculture, we may look forward to the recognition of the possibilities of combined genetical and cultural improvement programs in self-reproduced stands.