The Use of Forest Genetics in Forest Management

Bruce Zobel

What Genetics Is

All of you who have worked with and really observed trees realize that there is variation between and within species. Within any species there are differences between geographic regions, between sites in any one geographic region, and between trees on any given site. There are two main explanations for such variation.

One cause for variation is environmental differences. Trees vary because of the general site condition, soil characters, differences in spacing, overtopping and many other environmental reasons. The forester can do something about some of the environmental differences, while others he can't change. For example, poor diameter growth on a:good site can be greatly altered by spacing changes, but slow growth due to an extremely poor site is harder to remedy. Environmental variations have long been recognized by foresters and are the basis of silvicultural practices.

Not all variation can be explained by environmental differences. This is where genetics comes into play. How many of you have looked critically at an even-aged plantation and seen how different the trees are one from another? Some are taller than others, some have larger limbs, some yellow needle color, some drooping needles, some crooked stems. This list could be very long. Here we are dealing with a stand with as few environmental differences as possible -- same age, same species, same site as far as can be determined, same treatment. Yet the trees show considerable variation. This variation is so prevalent that it is nearly (if not impossible) to find two trees exactly alike in such a plantation. The cause of many of those variations are inherent -- in other words, genetic differences passed on from parents to progeny (offspring). There has been a great deal written about genetic versus environmental control. Genetics and environment cannot be separated -- both work together to form the tree we see. As an example, if we should plant an extremely genetically superior tree on a very poor site, it cannot grow as well as if it were planted on the best site. It might be better than other trees growing with it on the poor site, but it still won't look at all like the tree it would have been if planted on the best site. Here environment has partially determined what the tree will be despite its genetic makeup. Take this a step farther. If you took a southern pine and grew it under the most ideal of circumstances giving it the best soil, water and nutrients available you never could get it to grow to the age or size of a redwood. It is genetically a shorter-lived tree, and no change in environment can alter this fact.

There are two genetic terms which you should know because of their common use and utility. In the previous paragraph it was stated that the tree we see is the product of interaction between its genetic makeup and environment. This is termed the phenotype -- the phenotype is the tree we see growing. The genotype is the genetic makeup of the tree, the characteristics that will be passed from parent to offspring. The phenotype then, is the result of the interaction between the genotype and environment which has acted on the growing tree.

In forest genetics, we speak of characters that are subject to rigid genetical control, and of characters subject to only loose genetic control. The geneticist is most interested in rigidly controlled characters. They are little affected by environment, but the loosely controlled characters can easily be modified by varying the environment. For example, height growth is much more rigidly controlled, genetically, than diameter growth rate. On a given site, height growth is little affected by reasonable changes in spacing, and its improvement may require a geneticist's assistance. Diameter growth, by contrast, can easily be improved by a change in spacing.

Forest genetics is the study of genetic variations, a study of how rigidly the character is controlled, how it is inherited, and what will the progeny of two known parents be like under any given environment. Forest tree improvement, as those of us with a more practical outlook like to term it, is the application of genetic principles to silvicultural practices. It is an attempt to produce a more valuable product by coordinating standard silvicultural practices and genetic principles. We shall have more to say about this coordination later.

How to Improve Forest Trees

How can the geneticist go about the job of improving forest trees? There really are two approaches (selection and hybridization), although to be most effective, selection and hybridization must be used together.

The first approach is by selection. After a decision is made as to what is wanted in a tree, the forester goes into the woods and tries to find a tree as near as possible to the ideal. That is the approach on superior trees. The selectionist is taking the best that nature has produced over the centuries. Selection is the basis of genetics work -- it can yield results rather rapidly, but they will be of smaller magnitude than those achieved through hybridization.

Hybridization consists of crossing two individuals, each of which has desirable characters, in order to produce a tree that has a combination of these desired characters. The geneticist can, in effect, produce a new type tree by hybridizing -- a tree suited to a certain specific growth condition or with a certain desired character not found in any natural timber stand. Hybridization is spectacular and in some cases promises great improvement, but is difficult to get into commercial use. That is one of the geneticist's greatest problems -- to be able to produce in large quantities for commercial use stock of desirable hybrids or strains of trees he has developed and proven to be outstanding.

Value of Genetics to Forestry

Of first importance, genetics allows us to know something about the plants with which we are working and to take advantage of inherent variations between them. You never see a good cattle rancher save just any bull for use in his breeding herd -- he always keeps the best. The successful corn grower is not satisfied merely to hold down insects and weeds, and to fertilize and cultivate. One of his first concerns is to obtain seed of the corn best adapted to his locality for his desired product. The same should be true in forestry, where, in addition to protection and good management, we should start our crop with plants most likely to produce the heaviest yield of the desired product, whether it be pulp, lumber, poles, or gum.

It must be made clear that the geneticist will not produce a super tree, best suited to all products and growing conditions. Far from it. He can produce a tree suited to a particular product for a particular region, and that is all. For example, if we should be so fortunate as to isolate a superior tree ideally suited to pole production in North Carolina, this same tree might be of little value to Texas. Many factors such as climate, soils, and geographic strains, prevent extensive use of any one strain. It has always been true that with specialization comes restriction of general use. It is true here also. For example, in corn breeding a strain is produced for each different area and the superior strain in one locality may be absolutely worthless in the neighboring area which has different soils and climatic conditions.

The above raises a most important point, one often overlooked in a discussion of forest genetics. Before intensive research is undertaken, a decision has to be made as to the type of tree desired. Do we want a pulp tree with high specific gravity or one with low specific gravity? What type of fiber is ideal for the product we manufacture? Are we after drought resistance or insect resistance? These decisions must all be made early and taken into account when selecting material with which we are going to work. Each industry has to be able to know the type of tree desired. Many mistakes have, and are now being made in programs for selection of superior trees. Superior for what? Many persons have not asked this question and find themselves hopelessly lost. The same is true in management with a genetic slant. The type of tree for reproduction depends on what the industry wants for its final product.

It is now in order to mention a few things that may be achieved by the geneticist. Past research has already shown that gum yields can be increased by proper selection. There are numerous instances of insect and disease resistance being found in certain strains of trees. Faster growth is being sought, with better pruning and a resultant better wood quality. We are very interested in wood specific gravity and fiber length. Although there are no results to point to yet, preliminary investigation indicates the important part that genetics plays in determining these characters. Only research now in progress will give the final answer.

The geneticist can help both the silviculturist and the utilization man. He can help produce trees suitable for formerly unusable areas (such as P. attenuradiata). He can produce trees with morphological characters that result in a greater yield of a better product.

Genetics must be looked at realistically. It is not a panacea, which, by using some scientific hocus-pocus, will solve all forestry's ills. I look at it as a tool -- a tool of the silviculturist which must be co-ordinated with all his other tools. It is an additional tool that he must take advantage of to get the most from his land. Forest genetics is not an academic subject which has no application in practice. It can increase volume and quality -- in short, it can help to make more money for the forest landowner.

It must be realized that startling results cannot be obtained the first year or two. Tree improvement is a long time business, but what forestry enterprise is not? Some people become obsessed with the long-term nature of the work and say it's not worthwhile. The time element is being shortened, rapidly. We are discovering shortcuts and new methods that will produce earlier results.

When thinking of forest genetics, realize it is a tool, a very valuable one that enables you to know your tree and use its variation. Realize also it is of value in practical forestry only when used in coordination with other forestry knowledge. It is long term but not hopelessly so. Its value has been demonstrated in agriculture, but only after a number of years of preliminary work. Forest genetics is .present in the same preliminary stage, but by making use of methods and errors of past work, we should make quick progress. And above all, genetic principles can --and must-- be applied right now for the greatest financial returns from forest land.