Improve Your Future Forest Revenue Stream with Advanced Pine Genetics

Part I: Be Informed

The more you are informed about and understand the advanced pine genetics that are currently available on the market, the more you will be able to take advantage of those genetics to improve your future forest revenue stream.

Today, more than 30 million acres of loblolly pine plantations have been planted in the Southern United States, and the vast majority of those have used genetically improved planting stock. Of the more than one billion new loblolly seedlings planted each year, nearly every single one is a product of a tree improvement program.

The Value of Genetics in Increasing Forest Productivity

Genetics is a powerful tool when understood and used correctly. It has played and will continue to play a major role in many areas of human life, from food to medical needs. Forestry uses genetics, with some of the most sophisticated pine programs in the world located in the Southeastern United States. Improved seed, seedlings and trees have proven their worth for over 40 years.

As a landowner, you need to know that genetically superior seedlings increase timber revenue because of their faster growth rates, greater adaptability, increased disease resistance, improved wood properties and superior form.

The choice of what to plant often depends on your resources and goals. It is important to understand the various types of genetically improved seedlings available and the terminology used to describe these seedlings in order to choose the right seedlings for your location and your desired end results.

What type of genetically improved seedlings should you be using for your objectives?
What is a genetically improved tree?

Simply stated, a genetically improved tree comes from a strict selection process where the progeny (offspring) produced by the tree show superior performance for a specific trait (such as growth or form) or a combination of traits. Typically, the offspring of a genetically superior parent (tree) is tested across a wide variety of sites over a number of years, as the progeny are closely evaluated. This eliminates as much of the environmental influence as possible and exposes the true genetic worth of the individual.

The first step in developing genetically superior individuals is screening the natural population for individuals that exhibit the trait you want, such as fast growth. Branch tips of these selected individuals are grafted onto seedlings and placed into an orchard known as a first generation seed orchard.

Typically 25 to 30 selected individuals are grafted into this orchard. These 25 to 30 individuals are replicated so there is good pollen flow and, hopefully, an equal chance of random pollination. Depending on the species, it may take from three to ten years for the grafted trees to produce seed. The seed produced from the orchard and the resulting seedlings are genetically improved and represent first-generation improvement.

While these seedlings represent a specific level of improvement, this level can easily be increased by testing the resulting progeny to determine the best parents. This type of progeny testing allows the orchard manager to rank the genetic worth of the 25 to 30 parents and eliminate the lowest ranking from the orchard, thus increasing genetic gain. This type of orchard is referred to as a 1.5 generation orchard.

Remember that the goal of the tree improvement worker is to produce sustained generational gains. So while the seed orchard represents very high quality genetic parents, the tree improvement worker is also breeding a much wider array of genotypes looking for even greater performance through genetic recombination. This breeding process combines a much greater population size and specialized mating designs so that each generation will result in better parents for the seed orchard and ultimately better planting stock for landowners.

Seedling Terms

A variety of terms describe the level of genetic improvement as well as the types of seedlings. Here are some of them.

**Bareroot Seedlings**: Seedlings grown in a nursery bed, machine lifted and bundled in either bags or boxes. Most pine and hardwood seedlings are sold as bareroot stock.

**Containerized Seedlings**: Seedlings grown in some type of container, which can vary from small plastic tubes to pots. These seedlings have a more intact root system than bareroot stock. They have enhanced survival rates and provide a wider planting window.

**First, Second or Third Generation Open Pollinated (OP) Seedlings**: Specific levels of genetic improvement. These seedlings come from open-pollinated seed orchards and are known as half-sibs, since only the mother is known.

**Mass Control Pollinated (MCP) Seedlings**: These full-sib seedlings come from mating of specific parents (control-pollinated). MCP seedlings yield greater genetic gains than OP generational seedlings.

**Varietals**: These seedlings are genetically identical and can come from either vegetative propagation or somatic embryogenesis. They represent the current highest level of genetic improvement.

The Southern Forest Tree Improvement Committee issued a Position Statement in 1990 for Loblolly Pine.

Several points are still valid today:

- Uninformed use of a local seed source is not necessarily the best choice.

- Genetic differences among seed sources let informed landowners increase yields by wisely matching nonlocal sources to specific planting environments.
Generalized flowchart showing how genetically improved seedlings are developed through three generations in a traditional OP seed orchard approach.

In this representation we’re looking at only OP scenarios where the mother is known, but the father is unknown (pollen could originate from the seed orchard or outside pollen.) A “single family” is a group of seedlings produced from the seed of one specific, select individual (genotype) within a seed orchard. Seed from a single-family seed is sown separately in the nursery and planted separately in the field. In contrast, a seed orchard mix is a collection of cones from a number of individuals in a seed orchard. A seed orchard mix includes a number of OP families and so contains a greater degree of genetic variability than a single OP family planting.

The figure on the left shows the type of seedling performance that could theoretically occur when using an open-pollinated family, including red (poor tree performance), grey (average tree performance), yellow (above average) and green (best performing trees possible, i.e. sawtimber potential.)

Every year this type of seedling performance could change due to the type of pollen in the orchard.

However, even with outside contamination we’ve been able to make tremendous gains in genetic quality of OP seedlings.

So, if we can make tremendous improvements with open pollinated, what could be done with controlled pollination?

Variability
1. OP Seed orchards greatly influenced by outside pollen
2. Flowering phenology of parents included in the orchard
3. Weather patterns

Red: Poor tree performance
Grey: Average tree performance
Yellow: Above average tree performance
Green: Best tree performance possible

Deployment Population
Seed Production
1.0 Gen Seedlings

1.0 Gen Orchard
Seed Production
1.5 Gen Seedlings

2nd Gen Orchard
Seed Production
2nd Gen Seedlings

3.0 Cycle Orchard
Seed Production
3rd Cycle Seedlings

Breeding Population
Controlled Pollination
Progeny Test
Selections
Controlled Pollination
Progeny Test
Selections
(Continued)
Mass Controlled Pollination

• Mimics True Control Pollinations
• Takes advantage of knowing the performance of a good mother and father to use in the crosses

Full-sib seedlings (both mother and father are known) are the result of crossing two highly select individuals, which takes advantage of the known genetic quality of both parents. Full-sib seedlings were previously only used for research, as they were too expensive and time-consuming to produce in great quantities. However, today full-sib seedlings are being produced through an operational scale process known as mass-controlled pollination (MCP).

Mass-control pollination taking place in a seed orchard. Here a worker applies pollen from a single selection inside the bag to a selected female, making a full-sib cross.

Photos by ArborGen

Seed orchard photo showing bags that keep out outside pollen sources. Eventually the bags will decompose, allowing the mass-controlled pollinated cones to mature.

What you end up with in an MCP approach is a theoretical distribution mixture of trees, including red (poor tree performance), grey (average tree performance), yellow (above average) and green (best performing trees possible, i.e. sawtimber potential.)

You will get a higher percentage of above-average performing trees. The result will typically be higher returns per acre as well as reduced rotation lengths
**Varietal Production**

Varietal pine is the top genetic level of pine tree improvement today that is being used to regenerate sites. Varietal pine seedlings are produced through either hedging or somatic embryogenesis.

Hedging is a simple technique where young seedlings are cut back to produce numerous growing tips that are harvested and propagated into seedlings.

Somatic embryogenesis is a technique where an embryo is removed from the seed and placed into a system that allows it to multiply.

These embryos are grown on a specialized media to form seedlings that are identical copies of the original.

In this process, it is possible to place the resulting embryos in liquid nitrogen (cryopreservation) until the genetic testing is complete.

What you end up with in a varietal approach is a theoretical distribution mixture of trees, that are almost all the best performing trees possible. You can plant fewer trees per acre and still be assured to get the kind of tree that will net you the highest value.

Although varietals require a higher initial investment, they do provide the landowner with the highest quality genetic material available – and thus a greater financial return on forested land.
Why should you plant genetically superior seedlings?

*MCP (full-sib) families from the best second-generation parents can produce more than 50 percent volume gains. When you add in the improvements in stem form and disease resistance, stand value improvements may be twice the volume improvement.*

Any reduction in time it takes to grow a high quality tree that increases specific characteristics, such as growth or quality, means more profits. In fact, the profits from tree improvement have generally been high because of both the modest price of improved seedlings and the increased forest productivity and value realized from planting improved stock. Two questions that need answering are, “What is the best genetic material worth?” and “What are the financial benefits of planting the best genetic material?”

A rule of thumb has been that improved genetic seedlings have approximately a 10 percent gain in volume growth over unimproved seedlings. More recent estimates showed second-generation pine seed orchards throughout the South have approximately doubled the gains from the first generation. If you consider only the best OP families from rogued seed orchards, estimated genetic gains in volume growth are even higher, from 26 to 35 percent.

MCP (full-sib) families from the best second-generation parents can produce more than 50 percent volume gains. When you add in the improvements in stem form and disease resistance, stand value improvements may be twice the volume improvement.

Variatel pine planting stock currently represents the highest level of genetic improvement. When you order a single specific varietal, you receive seedlings that are genetically identical. Today, varietal pine planting stock is mainly from somatic embryogenesis, where a single embryo is multiplied to produce millions of trees if desired. As varietal stock does require a higher initial investment, you should carefully research the testing of that specific individual in your geographic area, clearly identify the end results that you desire and use the best silvicultural practices to allow these seedlings to reach their full potential.

What are limitations?

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- Genetic differences among seed sources let informed landowners increase yields by wisely matching nonlocal sources to specific planting environments.

Use of non-local seed sources should be matched with silvicultural practices that reduce environmental stress. This includes controlling weeds and insects. If you are not willing to use such practices, you increase risks. Individual OP families, full-sib families and selected varietals of loblolly pine display remarkable stability and predictability of growth performance across sites in the southern United States. As long as you match the proper seedlings to the climatic zones they are adapted to, family performance is rather stable.
Planting higher genetics comes with responsible management practices. Every year more acreage is planted to MCP and varietal seedlings. Landowners are taking advantage of higher genetics to increase both productivity and profits. However, planting higher genetics seedlings comes with responsibilities. Before making a choice on which genetics are best suited for your site and your desired end results, you should be fully aware of how these advanced genetic seedlings perform in your general area and what types of site preparation and silvicultural practices are necessary to ensure that your seedlings survive and reach their full genetic potential.

Use responsible management practices when planting advanced genetic seedlings in order to see end results more like the picture below than the picture above.

Part II of this series will cover Site Preparation, Seedling Care & Management.

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