# CAN FOREST TREE GENETICS CONTRIBUTE TO ARBORICULTURE?

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Abstract.--Forest tree geneticists working on conifers have assembled information on species adaptation, provenance variation and variation at the family level on several important North American and exotic forest tree species. From these investigations, insight has been gained into the population structure of our forest trees, seed transfer rules have been developed, and genetic parameters have been delineated. This information has been obtained in tests conducted in forest environments to meet forest management objectives.

The information will be of general value, but it will not meet the needs that are unique to the arborists, i.e., adaptation to the urban environment, salt damage and industrial pollutants, and others. To meet these needs, arborists must become engaged in tree breeding in their own environments; they must formulate their own objectives. When beginning their program, they should take advantage of the gene pools assembled by forest tree geneticists. A high degree of coordination in the future may benefit both arborists and forest tree geneticists.

Additional keywords: adaptation, provenance, salt damage, pollution, breeding strategy.

## INTRODUCTION

To put my comments into perspective, let me briefly describe the organization I represent and the location where I work: We are at the Forestry Sciences Laboratory of the Forest Service, USDA, at Rhinelander, Wisconsin. I am a member and leader of the "Genetics of Northern Forest Trees" Project, a staff of six scientists working on tree genetics. Rhinelander is located in northeastern Wisconsin. The climate is severe: hot, short summers with a growing season of approximately 115 days, with maximum temperatures between 90° and 100°. Winters are long and snow often covers the ground from November 15 to March 23 or even April 1. Winter temperatures between -35° and -40°C are not unusual. Although Rhinelander is a paper company town, air pollution in the region is low. Let me point out that our location and organization are not unusual in forest tree genetics projects. I shall return to this fact later in my presentation.

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In the description of our project, the stated mission is "to determine genetic, physiological, and other parameters necessary for efficient breeding ....; to develop alternative breeding strategies and plans for northern tree species; to develop efficient methods for mass producing improved strains of trees by sexual or vegetative propagation; and to breed fast-growing.... trees". The Work Unit description goes on to state that "increased yield of cellulose is the highest priority", and it justifies work on jack pine and white spruce because these two species are "important sources of pulpwood and well suited for intensively managed forest plantations". Clearly, our entire program is oriented towards the forest managers. Our customers are the national forests, the DNR's, and the wood industries engaged in forest management on company lands.

We are a Federal organization. Our Work Unit description sets the side-boards of our research and they are relatively rigid. We cannot pursue "hot leads" indiscriminatley. Again, this is not, I believe, a unique situation as most forest tree geneticists -- certainly those in public service -- must serve their clientele, the forest managers. Granted, some of the university-based researchers may have more leeway, but even they, by virtue of being centered in Departments or Schools of Forestry, cannot deviate widely from their clientele's needs.

## A GENERATION OF PROGRESS IN BREEDING CONIFERS

I will not attempt to give you a complete review of the conifer genetics research that has been in progress in the north-central and northeastern United States during the last 25 years. It parallels hardwood research closely and a detailed description would be very lengthy. Let me highlight work at the species level, outline results pertaining to populations, and describe variation at the family level.

### Testing Species

Species trials are often a first phase of tree improvement efforts. At Rhinelander, for example, we have attempted to grow between 28 and 30 species of spruce. A little less than half of these have developed reasonably well and they would be worth more extensive testing in other environments. Similar efforts are in progress with other species in other parts of the region. Work on five-needle pines has been concentrated in Ohio under Dr. Howard Kriebel, and several North American conifers native to other regions have been tested by Prof. Jonathan Wright in Michigan and elsewhere. More limited studies with the genus *Larix* have also been in progress in the Northeast and in the Central States.

The objective of species trials generally is to determine the extent of adaptation and performance under local climatic conditions. Where the opportunities have existed, responses to pollution have been included. In addition, many projects have included the development of species hybrids. Some of these hybrids show promise as new timber crops, but aside from the hybrid between the European and Japanese larch none can be mass produced for general planting at this point.

## Variation between Populations

Tree improvement programs traditionally begin with provenance tests, i.e., studies of the adaptive capabilities of different populations within species. At Rhinelander, for example, we have provenance tests in progress with jack pine, red pine, white pine, white spruce, black spruce, Engelmann spruce, blue spruce, Norway spruce, eastern white cedar, balsam fir, and tamarack. Extensive tests with other species are in progress elsewhere. They include: Scotch pine in Michigan and Pennsylvania; Douglas-fir, European black pine, and Ponderosa pine in Michigan; and Douglas-fir, eastern red cedar, and Scotch pine in Nebraska and North Dakota. In addition to these centers of testing, some of the experiments have been widely test planted in the North-Central States as a cooperative effort sponsored by the NC-99 organization.

From these studies we have accumulated information on vigor, phenological characteristics such as the time of flushing and related frost damage, the time of first flowering and fecundity, pest susceptibility or resistance, wood characteristics including specific gravity, fiber length, percent summerwood, and in some cases fibril angle. All these characteristics are of interest to the forest manager. In addition, many studies have included an evaluation of taxonomic characteristics and chemical constituents. The resulting response data have been used to determine variation patterns over the ranges of the species. Relations with growth responses and environmental conditions at site of origin have been established, and it has been possible to make seed transfer rules for some of the priority species that have been studied in the greatest detail. As a general rule of thumb, growing a seed source ca. 100 miles north of the site of origin may provide yield increases over those of local seed sources without jeopardizing hardiness. For some species superior and broadly adapted provenances have been identified: white pine from southern seed sources grows faster in parts of the Central States. Jack pine from some areas in southern Michigan grows faster than local sources of seed in parts of Wisconsin and Minnesota. And white spruce seed from southeastern Ontario grows fast in the Lake States and elsewhere within the southern range of the species.

## Comparison of Families

Extensive progeny tests have only been done on a few high priority species including red pine, jack pine, white pine, Scotch pine, white spruce, Norway spruce, and black spruce. Characteristics studied have included vigor, phenological characteristics such as flowering, seed set, cone abortion, frost injury, crown form, and in a few cases taxonomic characteristics such as cone color. In addition to simply finding out which family is the "best", a number of important genetic parameters have been determined. They include: (1) heritability estimates and selection differentials, combined these have enabled the breeders to predict potential genetic gains, (2) genetic correlations between characteristics; they assist the breeder in determining the feasibility of selecting for more than one characteristic at the same time, and (3) correlations between juvenile and mature characteristics; they help the breeder to determine the earliest date at which selection for a particular character is feasible.

Provenance and progeny tests require careful examination by skilled observers of many thousands of individual trees. Many unusual genotypes are identified as a result. Most can be propagated with ease and used for landscaping. The arborist is at an advantage in this regard *vis a vis* the forester because landscaping can accept greater unit costs than forestry can -- an important distinction between the two fields.

Here, let me mention one area of research that is an important adjunct to almost all forest genetics projects: in an effort to develop more efficient propagation methods, forest tree physiologists have devoted much time to the areas of growth control, the physiology of the rooting of cuttings and tissue culture. Arborists have benefited from this research: Container production of trees has been improved, and mist propagation techniques are better. Tissue culture propagation being developed in several laboratories nationwide and the new hormone derivatives being developed in our laboratories at Rhinelander potentially should be of great benefit.

## CAN FOREST TREE GENETICS RESEARCH CONTRIBUTE TO ARBORICULTURE IN THE FUTURE?

The answer, of course, is "yes"! But it is probably unrealistic to expect that the contribution will be a major one. Forest genetics research will not solve the major needs. As in the past, it will provide some important but general information. Seed source information on more species will become available and we will obtain more precise information on many species. High-yielding, i.e., fast-growing types will be developed and disease- and insect-resistant strains will be produced. But I suggest that the information and the materials developed by forest tree geneticists and breeders often will have somewhat limited value in the arborists' work.

Initially, I described our project location and our assignment. The contrasts between our environment at Rhinelander and the urban forester's and landscape architect's are major, I believe. Competing vegetation in many situations is much more important in my test environments than it is in urban forests, in highway plantings, or in amenity plantings near buildings. Temperature regimes certainly are strongly modified in the urban environment, particularly in the immediate vicinity of buildings. Pollution also, in many cases, is vastly different in the two environments. Therefore, the results from tree geneticists' tests will not reflect the responses in the urban environments. Specific selections adapted to unique urban environments may be needed; they cannot be made in forests.

I emphasized our assignment and stressed that we must meet forest managers' needs: adaptation to forest sites, high yields of quality fiber and wood, and in some cases pest resistance. In our region, at this point, the needs certainly are not new genetic types resistant to air pollution (pollution resistance may become important, but I suspect that will come a good many years from now). The forest managers' need in our region certainly is not damage from deicing salts. I would venture to say that it never will become a major concern of the forest managers. Therefore, there is no justification for the forest tree geneticists to work on these two major urban problems.

There may be other conflicts! Although foresters and landscape people may share a general interest in insect and disease resistance, their priorities might differ. Consider needle rust versus stem rots. I suspect, the forest manager would pick stem rot as highest priority, although needle rust would have a greater impact in the landscape -- other things being equal. Or, consider insects such as the gall-forming adelgids that cause little damage in terms of yield but have a major aesthetic impact on spruces. Such insects are of little concern to the forester.

I am suggesting that what forest tree geneticists can contribute to urban forestry, landscaping, and the Christmas tree industry will be limited by location, assignment, and user priorities. The conflicts will intensify in the future. In the early phases of a program, research is of a general survey nature and results are broadly applicable but as the generations of breeding populations advance, they will become more specialized with a focus on increased yield of specific forest products. They are less likely to yield information or selections of use to the arborists.

## WHAT OF THE FUTURE?

I suggest:

(1) That arborists, if they are to solve some of their major plant material problems through genetics, must become engaged in breeding activities in their own environments with their own specific breeding objectives.

(2) That arborists can gain much by beginning such efforts with the gene pools now in use in forest tree breeding. The gene pools represented by the species, provenance, and progeny tests established by forest tree geneticists during the last 50 years are the most significant contributions tree breeders can make to the arborists.

(3) Arborists should, I believe, develop breeding strategies that are compatible with the strategies now being developed by forest tree breeders. Ornamental tree breeders and forest geneticists should progress with breeding along parallel, but independent paths. A high degree of coordination and opportunities for exchange of breeding material may benefit both fields.

## CONCLUSION

Most of the benefits arborists have gained from forest geneticists in the past have been general biological information or random spin-off. This flow of information and materials will continue in the future. However, only if the arborists become directly engaged in breeding efforts aimed at their specific problems can they expect to find genetic solutions to their needs. If they begin such programs in coordination with tree breeders and use the gene pools assembled by the forest tree geneticists, both fields could benefit greatly in the future.

## REFERENCES

Available knowledge regarding the genetics of some of the most important North American forest tree species has been published by the U.S. Forest Service, Department of Agriculture in a series of Research Papers.

This "GENETICS OF ........" series is available from: Forest Service-USDA, P.O. Box 2417, Washington, D.C. 20013.