

Long-term Forest Genetics Research in Northeastern North America

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Tree breeding research began in the Northeast in the early 1920s, when the Oxford Paper Company of Rumford, ME sponsored hybrid poplar breeding work by Dr. Ernest Schreiner. This poplar research was one of the earliest full-time tree breeding activities in the United States; and since that time various organizations in the northeast have been continuously active in tree breeding and genetics research (Wright 1981). In 1936, oversight of the poplar breeding and research was transferred to the USFS Northeastern Forest Experiment Station in Durham NH (Demeritt, M.E. Jr. 1981). For the rest of the 20th century, the Durham station remained active in long-term forest genetics research on a variety of species, including the establishment of many research plantations on the Massabesic Experimental Forest near Alfred, ME, and elsewhere in the region. Various universities in New England also maintain long-term forest genetics research projects. The number of long-term genetic tests existing throughout the northeast is very large; the following summary is not complete, but will give examples of a few of these long-term forest genetics projects in the northeastern region and address some of the advantages and difficulties of long-term genetics research.

Eastern and Western White Pines

Eastern white pine (*Pinus strobus* L.) was the object of much genetic research in the northeast during the period 1950–1990, largely through the efforts of the USFS station in Durham. In 1959–60, a rangewide provenance test was planted at 11 locations in the northeast, as well as other locations outside the region. Results of these provenance tests have been reported through age 16 (Garrett et al. 1973; Demeritt and Kettlewood 1976). These provenance tests are now 45 years old, and although comprehensive measurements from later ages have not been published for the entire series of test sites, most of these plantations are still believed to be extant and in good condition. The plantation in Bradley, ME, for example, was recently thinned in a manner to retain identification of individual trees and to allow for continued good growth. The Bradley plantation was also measured at age 30, at which time average dbh ranged from 6.98 inches (VA provenance) to 10.7 inches (NS provenance) (Carter, unpublished data).

The search for white pines resistant to white pine weevil attack led the Forest Service research group to establish a trial of western white pine (*P. monticola* Dougl. ex D. Don) and putative eastern x western white pine hybrids on the Massabesic forest in 1971. Wilkinson (1981) reported that at age 10, the western white pines and putative hybrids had only 1/3 to 1/10 as many weeviled trees as the eastern white pine. I recently re-examined this plantation at age 31, at which time 67% of the western and hybrid pines were unweeviled, as compared to only 33% of the eastern white pines (Carter 2002). Additional selections of western white

pine planted by the USFS Durham genetics project in 1983 in Maine and New York have recently been remeasured and confirm the weevil resistance of western white pine (Pike et al. 2003; Caron and Carter 2003).

Sugar Maple

Following years of research to establish a genetic basis for inheritance of sap sweetness in sugar maple (*Acer saccharum* Marsh.), the US Forest Service initiated a program during the 1950's to locate high sap-sugar trees. Half-sib progeny tests were established in 1960 near Williamstown, MA and Underhill, VT. Sap sugar content was tested from age 13 to 23 in these progeny tests to determine effective selection strategies for sweet trees (Wilkinson 1985). Kriebel (1989) worked with 27-year-old grafted sweet-tree selections from Ohio, Vermont, New York and Massachusetts to demonstrate that these seed orchard trees averaged 4.2% sap sugar, a considerable improvement over unselected trees. Eventually over 21,000 sugar maples in the northeast were tested, and the best selections were clonally propagated into seed orchards throughout the Northeast. Currently, seed orchards are maintained in Grand Isle, VT, West Salisbury, CT, and at the Uihlein field station near Lake Placid, NY (Staats et al., 2005; University of Vermont 2005). Plantings of sugar maple seedlings from these seed orchards are currently being established through cooperation between extension agents and private landowners in New York and Pennsylvania (Krasny et al., 2001).

Land Grant Universities

The land grant universities throughout the Northeast have been involved with forest genetic research since mid-twentieth century, and most of them maintain numerous long-term field studies in forest genetics. Genetics research often involved collaboration between various land-grant universities and state, federal, and private forestry organizations in the Northeast. Collaboration and communication among researchers was facilitated by a long-running federally-funded Hatch project which supported research at several northeastern universities, as well as by the biennial Northeastern Forest Tree Improvement Conferences which were held at various sites in the Northeast from 1955 to 1993. The proceedings of these conferences were published and provide a wealth of information regarding early forest genetics research and the establishment of long-term study sites.

To give just one example of the number of field sites established during this time, from 1974 to 1990 the University of Maine was responsible for the installation of 77 long-term field studies in forest genetics. These represent species trials, provenance studies, and progeny tests for 18 different species. The great majority of these plantations are still in existence and documentation (seed sources, planting maps, interim measurements, etc.) is maintained at the University. Other universities in the region also maintain numerous long-term genetic tests.

Eastern Canada

At about the same time that hybrid poplar research was beginning in the Northeastern US, forest genetics research was also underway in Canada. Much early work was based at Petawawa, Ontario (Canadian Forest Service 2005). Over 300 genetic test plantings still exist there and are available for ongoing research activities.

Applied tree improvement programs began in eastern Canada in 1976 with the cooperative New Brunswick Tree Improvement program which originated as a joint effort by forest industry, provincial and federal governments, and universities. The NBTIC seed orchards are now producing adequate supplies of black spruce, jack pine, and white spruce seed to meet all planting needs in the province. This first round of genetic selection in black spruce is anticipated to result in volume gains of 18% to 20%, with even larger gains projected from second-generation selections (McInnis and Tosh 2004). The provinces of Quebec, Ontario, and Nova Scotia maintain similar long-term applied tree improvement programs.

Thoughts on the Utility and Maintenance of Long-term Genetic Trials

Most genetic field trials are initially established to answer particular questions related to seed source variability in survival and growth, insect and disease resistance, sap sweetness, etc. Due to time constraints and institutional pressures for “new research,” publication of results from field trials often occurs early in the life of the experiment and subsequent maintenance and research output from the trials may be of low priority. However, these older plantings have great utility in answering important questions about potential changes in genetic responses as trees age, about the stability of insect and disease resistance mechanisms, and about the genetic aspects of growth and yield. They also are valuable sources of data to provide answers to new questions which were not anticipated when the trials were initiated. For instance, provenance tests in the Northeast and in Canada have been revisited to gain important insights regarding the likely response of native species to predicted future climate change (Carter 1996; Johnsen et al. 1996).

In order to provide this long-term information, however, field studies must be adequately maintained and documented, both in the field and in written records. At times the organizations involved with long-term studies may shift, as demonstrated by the sugar maple and white pine research described earlier. As personnel and institutional priorities change, one of the greatest challenges may be maintaining an awareness of the existence of these long-term field trials.

Sponsoring Research Organization	Species	Trait of Interest	Type of test	Year Initiated
USFS Northeastern Forest Experiment Station, Durham, NH	eastern white pine	growth and survival	provenance	1959
USFS Northeastern Forest Experiment Station, Durham, NH; continued by University of Maine	western white pine	resistance to white pine weevil	progeny	1971
USFS Northeastern Forest Experiment Station; continued by Proctor Maple Research Center, University of Vermont, Underhill Center, VT	sugar maple	sap sweetness	progeny	1960
USFS Northeastern Forest Experiment Station; continued by Cornell University, Uhlein Sugar Maple Research Field Station, Lake Placid, NY	sugar maple	sap sweetness	seed orchard and progeny tests	1960
University of Maine, Orono	black spruce, white spruce, Norway spruce, tamarack, and 14 other species	growth traits	provenance and progeny tests at 77 locations	1974
New Brunswick Tree Improvement Council (Canada)	black spruce, jack pine, white spruce	growth traits	seed orchards, progeny tests	1976

Table 1. Long-term forest genetics research projects discussed in this paper.

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