# AN ACCELERATED OPERATIONAL-SCALE TREE IMPROVEMENT PROGRAM FOR NORTHERN RED OAK

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Abstract--Procedures for an accelerated tree improvement strategy for northern red oak are discussed. The improvement scheme is directed toward juvenile trait selection, primarily early height growth and survival to enhance outplanting success. A timetable of activities and estimated labor and materials is also presented.

Additional Keywords: Quercus rubra, early selection, hardwood regeneration, long rotation forestry.

## INTRODUCTION

Clearcutting, shelterwood and selection harvests are the principal silvicultural systems that are used to foster the establishment of natural reproduction of hardwood species. Although these silvicultural systems are often successful in regenerating harvested stands, the establishment of desired species, particularly oak, at optimal stocking levels is variable and frequently unpredictable. The problems of obtaining desired species composition and stocking levels notwithstanding, the use of silviculture systems to promote natural regeneration will remain the principal mode of hardwood reforestation because of its low cost nature. Artificial regeneration is, however, a viable option to effectively supplement natural reproduction (Johnson, 1984). Artificial regeneration offers better control of species composition and stocking levels (Farmer, 1973). Hardwood plantings on upland sites have been unsuccessful when planted seedlings fail to initiate and sustain rapid early height growth and thereby effectively compete with naturally occurring vegetation. Steiner (1986) reported large seedling growth differences associated with parent seed sources. Genetic selection for early height growth is therefore possible and could contribute much to enhancing planting success.

The tree improvement strategy being proposed here is a refined version of the one Steiner (1986) outlined at the 1986 Northeastern Area Nurserymen's Conference. McGee (1968) and Beineke (1979) have suggested similar short-term programs for genetically improving the early performance of northern red oak ( Quercus rubra L.). The proposed tree improvement scheme requires only a low investment, and can be accomplished with a minimum of field and nursery personnel.

The objective of our scheme is to develop a reliable source of genetically improved planting stock as rapidly as possible. Selection efforts in this program will, therefore, be directed toward juvenile traits - survival and early height growth. Genetic improvement of hardwoods using a conventional approach would not be realized for 20-40 years. It is anticipated that improved planting sources will be available within 7-10 years after initiation of the program. The program has a significantly reduced

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time frame because the seed production or seed orchard establishment phase is eliminated: commercial seed collections will be made from wild trees that have proven genetic worth. These collections should meet the current annual nursery demand for hardwood seedlings in Pennsylvania. Plans for seed orchard establishment should, however, be developed as hardwood seedling demands become better defined. Figure 1 outlines the selection and testing phase and how it will be translated into genetically improved commercial seed collections.

This tree improvement program has been structured for the Pennsylvania Bureau of Forestry operations. However, with some modification, the program could be easily adapted to other state or industrial programs.

## TREE IMPROVEMENT STRATEGY

### Selection of Mother Tree Candidates

The initial phase of the hardwood tree improvement program will involve the selection of candidate trees. The low cost nature of the program and ineffectiveness of wild tree selection for improving juvenile (Snyder, 1969) and mature (Purnell and Kellison, 1987) traits dictate reduced selection standards. The inclusion of average to above average candidate trees will expedite rapid selection of the base population (150-200 trees). The selection phase will be carried out over a 4-5 year period, with a minimum of 35 selections required per year. However, completion of the selection phase will be dependent however on favorable acorn production. A significant number of candidate trees are expected to be eliminated from the program because of unacceptable performance of their progeny. The elimination of 75 percent of the original selections will leave 40-50 selections from which to make acorn collections for annual nursery requirements.

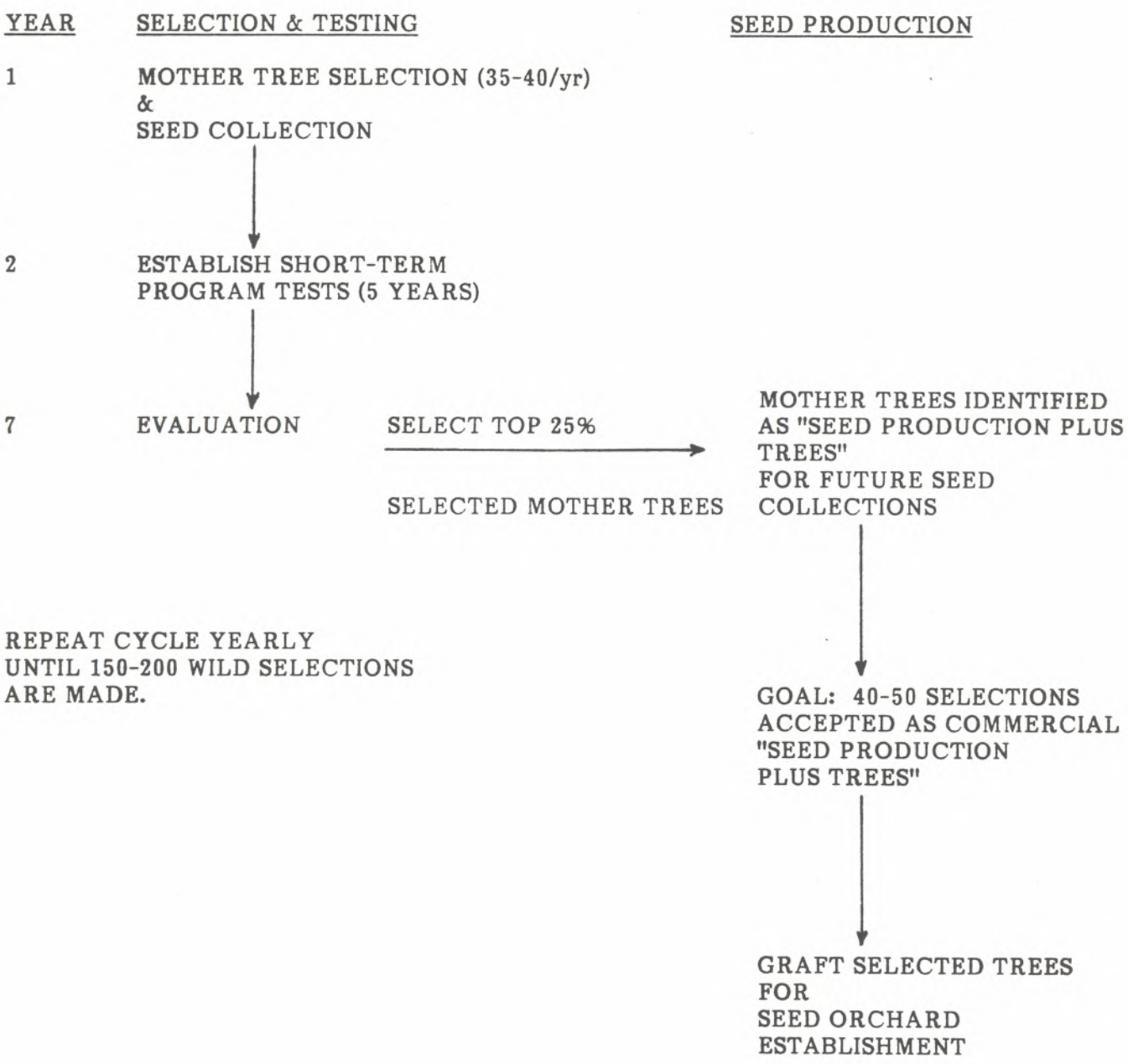
Since it is intended that candidate trees will eventually supply the acorn needs for nursery production, selection will be based on the occurrence and amount of acorns on the candidate tree. Candidate trees should also exhibit average growth and form and be in the dominant or co-dominant canopy. Trees exhibiting severe stem or bole defects will be rejected. Multiple stem trees can be accepted as candidate trees if the forking is close to ground level, suggesting stump sprout origin.

No restrictions will be put on site locations that are considered for candidate tree selection. Natural forest stands are favored because tree development will be most typical under these growing conditions but trees located in parks or cemeteries can be considered. The overriding importance with any tree selected is that access to the tree will be possible for a minimum of 10 years. This will ensure that acorn collections for nursery and research purposes can be made without hindrance.

Multiple selections within a stand can be made providing the crowns of adjacent trees do not overlap and are at a sufficient distance (circa 100 ft.) to prevent mixing of acorn seed lots from neighboring trees.

Good record keeping is an essential ingredient to any tree improvement program. Selection standards for this program require few tree or stand measurements, but do require a detailed map of individual candidate tree locations with prominent physical

**FIGURE 1. FLOW DIAGRAM OF SHORT-TERM HARDWOOD TREE IMPROVEMENT PROGRAM**



reference points to assist in future relocations. Painting a band around the tree bole and monumenting with metal identification tags will help in relocating candidate trees during future acorn collections.

Plans are being made to establish candidate trees that have proven genetic worth in a grafted clone bank. The establishment of a clone bank will ensure that selected trees will be preserved in the event the original wild selections are lost.

Progeny Test Design

Because the improvement objective of this tree improvement program involves juvenile traits, progeny tests will be of short-term duration (4-5 years). The progeny test objective is to identify families which initiate and maintain rapid height growth. The inability of planted red oak to initiate and sustain rapid early height growth has been cited as the principal factor in planting failures (Johnson, 1984).

The progeny tests will be planted in at least two locations typical of sites undergoing regeneration cuts on state forest lands. Test site locations will be established on the Allegheny Plateau and the Ridge and Valley physiographic regions. Each annual test will include the progenies of 35-50 families, each planted in five replications and represented by five-tree non-contiguous plots at a 4' x 4' spacing pattern. Acreage required for each plantation will range from 0.32 - 0.46 acres.

Test locations will be selected and designed at least one year before planting. Advanced planning will permit choosing the best sites available, facilitate field planting as replication boundaries and family plots will be located on the ground and on planting maps, and allow efficient pre-planting herbicide treatments. Test seedlings will be hand planted according to the pre-randomized maps. Because of the potential loss of seedlings by deer browsing, all test plantings will be planted within mechanical or electrical enclosures. Test plantings will be established in conjunction with Bureau of Forestry fencing practices.

Evaluation of Candidate Trees

Height and survival measurements will be taken at the end of the 1st through the 5th growing seasons. Additional evaluations such as insect or disease damage and stem form will be included as warranted. Candidate trees with progeny of proven superiority will be designated "Seed Production Plus Trees" and steps will be taken to ensure their protection as seed sources for future nursery production. As candidates are added to the roster of Seed Production Plus Trees, an increasing proportion of annual seedling production by Bureau nurseries will come from these superior seed sources. Seedlings from Seed Production Plus trees will qualify for "blue tag" certification.

The long-term status of the progeny test after final evaluation is uncertain at this time. The following options are available.

1. Use as a source of advanced generation selections. Select best individuals within best families and graft material for 2nd generation seed orchard establishment.

2. Develop seedling seed orchards out of tests by removing poorly performing families.

3. Remove the test and replant area with another short-term test.

## SUMMARY

The proposed hardwood tree improvement program is a pragmatic approach to help solve the problem of hardwood planting. Selecting seed sources that have good survival and rapid juvenile height growth will increase the probability of successful seedling establishment.

The procedure for selecting candidate trees and testing their progeny for juvenile growth is a practical method to accomplish the program objectives. After four or five phases of selection and testing, an adequate number of genetically proven selections (40-50) will be available for general acorn production. The final selections chosen represent the genetic base for future breeding activities.

The level of hardwood seedling production is currently low at the Pennsylvania State Forest Nurseries; approximately 45,000 red oak seedlings were produced in the state nurseries in 1988. A comparable production figure is expected in 1989. Given this level of production, acorns collected from seed production plus trees can adequately satisfy nursery requirements. Increased nursery production should, however, be anticipated as successful tree planting techniques are developed. Plans should therefore be made to develop systems for increasing acorn production. Such systems include grafted or seedling seed orchards.

Little is presently known of the correct cultural procedures for stimulating acorn production. Flower stimulation, acorn protection from diseases and insects and collection procedures are not well documented. It is anticipated that oak seed orchard management may be less efficient than with pine species because of irregular acorn crops and because acorns cannot be effectively stored for long periods.

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Appendix I

## Time Table of Hardwood Tree Improvement Activities

| Activity | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1988** | | | | | | | | | | | | |
| Training Sessions | | | | | X | X | X | X | | | | |
| Candidate Tree Selection | | | | | | | | X | X | X | | |
| Acorn Collections | | | | | | | | | X | X | X | |
| Establish Progeny Test in Nursery (Prg 1) | | | | | | | | | | | X | |
| **1989** | | | | | | | | | | | | |
| Maintenance of Test in Nursery (Prg 1) | | | | X | X | X | X | X | | | | |
| Locate, Layout and Herbicide Prg 1 Test Site | | | | | | | X | X | | | | |
| Candidate Tree Selection | | | | | | | | X | X | X | | |
| Acorn Collections | | | | | | | | | X | X | X | |
| Establish Progeny Test in Nursery (Prg 2) | | | | | | | | | | | X | |
| **1990** | | | | | | | | | | | | |
| Establish Field Tests (Prg 1) | | | | X | | | | | | | | |
| Maintenance of Nursery and Field Progeny Test | | | | | X | X | X | X | X | | | |
| Locate, Layout and Herbicide Prg 2 Test Site | | | | | | | X | X | | | | |
| Candidate Tree Selection | | | | | | | | X | X | X | | |
| Acorn Collections | | | | | | | | | X | X | X | |
| Establish Progeny Test in Nursery (Prg 3) | | | | | | | | | | | X | |

Appendix I (continued)

| Activity | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1991** | | | | | | | | | | | | |
| Annual Measurement of Prg 1 | | | X | | | | | | | | | |
| Establish Field Test (Prg 2) | | | | X | | | | | | | | |
| Maintenance of Nursery and Field Progeny Tests | | | | | X | X | X | X | X | | | |
| Locate, Layout and Herbicide Prg 3 Test Site | | | | | | | X | X | | | | |
| Candidate Tree Selection | | | | | | | | X | X | X | | |
| Acorn Collections | | | | | | | | | X | X | X | |
| Establish Progeny Test in Nursery (Prg 4) | | | | | | | | | | | X | |
| **1992** | | | | | | | | | | | | |
| Annual Measurements of Prg 1 and Prg 2 | X | X | | | | | | | | | | |
| Establish Field Test (Prg 3) | | | | X | | | | | | | | |
| Maintenance of Nursery and Field Progeny Tests | | | | | X | X | X | X | X | | | |
| Locate, Layout and Herbicide Prg 4 Test Site | | | | | | | X | X | | | | |
| Candidate Tree Selection (continued if necessary) | | | | | | | | X | X | X | | |
| Acorn Collections | | | | | | | | | X | X | X | |
| Establish Progeny Test in Nursery (Prg 5) | | | | | | | | | | | X | |

Appendix I (continued)

| Activity | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **1993** | | | | | | | |
| Annual Measurement of Prg 1, Prg 2, and Prg 3 | X | X | | | | | | | | | | |
| Establish Field Test (Prg 4) | | | | X | | | | | | | | |
| Maintenance of Nursery and Field Progeny Tests | | | | | X | X | X | X | X | | | |
| Locate, Layout and Herbicide Prg 5 Test Site | | | | | | | X | X | | | | |
| | | | | | **1994** | | | | | | | |
| Annual Measurement of Prg 1, Prg 2, Prg 3, and Prg 4 | X | X | | | | | | | | | | |
| Establish Field Tests (Prg 5) | | | | X | | | | | | | | |
| Clone Bank Establishment | | | | X | X | | | | | | | |
| Maintenance of Field Progeny Tests | | | | X | X | X | X | X | | | | |
| | | | | | **1995** | | | | | | | |
| Annual Measurement of Prg 1, Prg 2, Prg 3, Prg 4, and Prg 5 | X | X | | | | | | | | | | |
| Continue Clone Bank Establishment | | | | X | X | | | | | | | |
| Maintenance of Field Progeny Tests | | | | X | X | X | X | X | | | | |
| Prg 1 Mother Trees Selected for Nursery Collection | | | | | | | X | | | | | |

Appendix I (continued)

| Activity | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **1996** | | | | | | | |
| Annual Measurement of Prg 2, Prg 3, Prg 4, and Prg 5 | | X | X | | | | | | | | | |
| Continue Clone Bank Establishment | | | | X | X | | | | | | | |
| Maintenance of Field Progeny Tests | | | | X | X | X | X | X | | | | |
| Prg 2 Mother Trees Selected for Nursery Collection | | | | | | | X | | | | | |
| | | | | | **1997** | | | | | | | |
| Annual Measurement of Prg 3, Prg 4, and Prg 5 | | X | X | | | | | | | | | |
| Continue Clone Bank Establishment | | | | X | X | | | | | | | |
| Maintenance of Field Progeny Tests | | | | X | X | X | X | X | | | | |
| Prg 3 Mother Trees Selected for Nursery Collection | | | | | | | X | | | | | |
| | | | | | **1998** | | | | | | | |
| Annual Measurement of Prg 4 and Prg 5 | | X | X | | | | | | | | | |
| Continue Clone Bank Establishment | | | | X | X | | | | | | | |
| Maintenance of Field Progeny Tests | | | | X | X | X | X | X | | | | |
| Prg 4 Mother Trees Selected for Nursery Collection | | | | | | | X | | | | | |

Appendix I (continued)

| Activity | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **1999** | | | | | | | |
| Annual Measurement of Prg 5 | | | X | | | | | | | | | |
| Continue Clone Bank Establishment | | | | X | X | | | | | | | |
| Prg 5 Mother Trees Selected for Nursery Collection | | | | | | | X | | | | | |
| | | | | | **2000** | | | | | | | |
| Complete Clone Bank Establishment | | | | X | X | | | | | | | |

Appendix II

Estimated Annual Labor and Material Needs for Hardwood Tree Improvement Program

| Activity | Labor | Material |
|---|---|---|
| Tree Selection | -Hardwood Seed Coordinators<br>-One man day/tree (Annual goal of 35 candidate trees) | -Paint for monumenting candidate trees |
| Acorn Collection | -Forest Geneticist and Hardwood Seed Coordinators<br>-One-half man day/tree | -Cloth bags (50)<br>-Metal tag labels |
| Establish Progeny Test in Nursery | -Forest Geneticist and Nursery Staff<br>-5 man days/test | -Metal tags<br>-Laths for marking nursery plots (1000 ft.) |
| Layout of Progeny Test (Estimated time and material for 2 location progeny test) | -Forest Geneticist, District and/or PCC Personnel<br>-Four man days/test for herbiciding and field layout<br>-Twenty man days/test for deer exclosure construction | -Metal stakes to mark family plots and replication corners (540)<br>-Wire flagging to mark individual planting positions (2500)<br>-Herbicides for pre-planting weed control<br>-Supplemental deer exclosure |
| Progeny Test Establishment | -Forest Geneticist and District and/or PCC Personnel<br>-Ten man days/test | -Planting bars<br>-Planting acreage per test planting 0.5 acres. Two test sites required.2/ |
| Annual Measurements | -Forest Geneticist and District Personnel<br>-Four man days/test | -Measurement forms |
| Annual Maintenance of Progeny Test | -Forest Geneticist and District and/or PCC Personnel | -Herbicides |
| Clone Bank Establishment | -Forest Geneticist and Nursery Staff | -Rootstock<br>-Nursery space for lining out stock<br>-2-3 acres for outplanting grafted stock |

2/A total of five acres will be required for five years of progeny testing