GENETIC IMPROVEMENT FOR PRAIRIE TREE PLANTINGS

by William R. Schroeder

Abstract. Planting of seed-propagated native trees and shrubs and the need for genetically diverse plants for sustainable tree plantings is emphasized. Tree improvement efforts, specifically with green ash and bur oak, under way at the PFRA Shelterbelt Centre are described.

Tree planting has been an important activity in the Great Plains for many years. The importance of trees in the prairie landscape is widely accepted. Prairie 'forests', urban and rural, face many obstacles. We are planting trees on sites where they do not naturally occur and in many cases it is a major accomplishment if they survive. Once established, trees may be subjected to damaging climatic extremes which can predispose them to damage by insects and diseases.

One of the keys to healthy tree plantings is genetic diversity. Unlike humans, plants cannot move from or modify their environments. In nature, plants survive by accumulating genetic variations which allow them to adapt to local conditions. The use of plants that are not locally adapted can result in immediate mortality, delayed mortality, or poor growth.

Most of the woody species planted in the prairie landscape are the result of the efforts of a few early plant collectors. Many of these introductions originated from cultivated plants in milder climates of Europe and Asia as well as hybrids that occurred naturally in early gardens. These plants may be fairly hardy but few were selected specifically for planting in the harsh environments of the northern Great Plains.

Uniformity has been a major factor in plant selection and is easily accomplished using asexual propagation. Great effort has been given to producing the 'perfect tree.' Cloning is a departure from natural processes; not so much that it does not occur, but in nature there is also seed propagation of every species. The convenience and short-term success of cloning is offset by the fact that we are perpetuating narrow gene pools that may be destroyed by insects or disease.

Vegetatively propagated clones have their place in our landscapes. However, to rely entirely on clonal monocultures is a dangerous practice. Often the origin of clones is not known and hence information on the ecology of the parent and its adaptive range is lacking. The basis for most large-scale tree planting programs, urban or rural, should be seed-propagated native plants. By doing this we are able to match trees with sites using knowledge of their natural range. Utilizing native trees and shrubs from local seed for our boulevards, parks and shelterbelts provides the framework for maintaining genetic diversity. Native plants cannot totally replace exotic species or clones; there will always be the need for interesting exotic species for specialized plantings and sites or areas where native trees will not grow or perform poorly.

This paper reports on tree improvement activities under way at the Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Centre at Indian Head, Saskatchewan; specifically the development of hardy, seed-propagated green ash (*Fraxinus pennsylvanica*) and bur oak (*Quercus macrocarpa*).

Early Programs

The PFRA Shelterbelt Centre, since its beginning in the early 1900s, has played a major role in tree improvement for the Canadian prairies. An early report by Norman Ross, Nursery Superintendent from 1902 to 1941, described the evaluation of numerous tree species under prairie conditions (9). These first tests concentrated on screening exotic species for hardiness and adaptation to the prairie environment. Little or no emphasis was placed on native species, genetic improvement or diversity. Scots pine (*Pinus*

sylvestris), Colorado spruce (*Picea pungens*), caragana (*Caragana arborescens*), Siberian elm (*Ulmus pumila*) and Siberian larch (*Larix sibirica*) evaluated in these early programs, have since become important species in prairie shelterbelts. In addition to shelterbelt species, considerable effort was given to development of hardy ornamental and fruit varieties for prairie settlers.

The first genetic improvement programs concentrated on hybridization and evaluation of poplars. The most notable result was the development of the clone Populus x 'Walker', which was selected from open-pollinated seedlings of Populus deltoides in 1944 (6). This clone continues to be the most commonly planted poplar in the Canadian prairies. Major improvement programs from 1947 to 1981 included Colorado spruce (3), caragana (2), Scots pine (4), Japanese elm (*Ulmus japonica*) (7) and Siberian elm (5). Native species such as green ash and bur oak were not considered for tree improvement during this period.

Current Program

Tree improvement at the Shelterbelt Centre underwent significant changes in the 1980s. A tree improvement strategy was prepared describing the rationale, program objectives and breeding approaches for important species. Maintaining genetic diversity in tree plantings is a major objective in the program. Emphasis has been placed on developing improved seed sources rather than relying on clonally propagated plants.

The first problem identified was the absence of reliable and tested seed sources for tree planting in the prairie region. Secondly, there is concern that species monocultures, especially of green ash and caragana, are being planted and that there is a need for additional native and in some cases exotic tree and shrub species. Finally, genetically improved cultivars and seed sources which grow faster, tolerate drought and are resistant to insects and disease, are required.

Because of the commitment to developing genetically diverse tree plantings, improvement programs have concentrated on developing superior seed-propagated populations. Plant acquisition is based on the principle that we should have specific information about the seed, about its original source and preferably not collected from arboreta where hybridization is possible. The number of collections for a specific species depends on the size of its natural distribution. For example, green ash, a species with considerable variation over a wide habitat range of North America, would be represented by a large number of seed sources that depict its diversity and give us the opportunity to understand more about its adaptive range.

The steps involved in current improvement programs include:

- Sample the native range of the species, collect seed and assess the range of genetic variation in major traits using provenance tests.
- Superior trees are selected from provenance tests, vegetatively propagated and planted in clone banks.
- Superior trees are crossed and their progeny evaluated on a variety of sites.
- Based on the performance of progeny, trees in the clone bank are rogued leaving only trees that produce progeny with the desired traits.

Current tree improvement programs are focusing on native species, specifically green ash, bur oak, hackberry (*Celtis occidentalis*), cottonwood and choke cherry (*Prunus virginiana*). Major seed collections of native shrub species such as buffaloberry (*Shepherdia argentea*), rose (*Rosa* sp.), hawthorn (*Crataegus* sp.) are also being initiated.

Green ash. Green ash is an important species in the northern Great Plains. It is one of the most commonly planted trees on urban and rural sites. Native to much of North America, there is considerable genetic variability in the species. A major problem for green ash is the ash bark beetle (*Hylesinus* sp.) and ash borer (*Podosesia syringae*). Both insects are seldom a problem in native stands but can be severe in planted trees that are under stress.

Green ash is the most widely distributed of all North American ashes. Its range extends from Cape Breton Island and Nova Scotia to western Saskatchewan and southward to central Texas and northern Florida. In the northern Great Plains most of the native populations occur on alluvial soils of river and creek bottoms. Upland sites are

generally too droughty to permit natural regeneration. Looman and Best (8) describe two different varieties of green ash found in the prairies, var. *subintegerrima* (west to Saskatchewan) and var. *austinii* (west to Manitoba).

Bagley (1) found that green ash populations from the arid, northwestern part of the range (Montana) were more drought tolerant than those from the central Great Plains (Nebraska). A marked decrease in size of both parent trees and their progeny was noted from south to north and east to west. Bagley further noted that a green ash provenance may be safely planted as much as three degrees latitude north of its native site. In his study Bagley noted that northern provenances grew more slowly than local sources when grown south of their native origins.

In 1985, a comprehensive green ash tree improvement program was initiated at the Shelterbelt Centre. The purpose of this project is to evaluate the genetic variability in green ash from diverse habitats in the northern Great Plains. Seed was collected from the native range of green ash in Saskatchewan and Manitoba as well as selected areas of North Dakota, South Dakota and Nebraska. Provenance tests were planted in 1989 at four sites in Saskatchewan and two in Manitoba. Also included in the project is selection of superior phenotypes from native stands and establishment of clonal seed orchards.

Green ash from several mesic and xeric sites were tested for drought tolerance (10). It was found that seed collected from xeric sites had superior drought tolerance compared to trees from mesic sites. Because of improved drought tolerance it is likely that they will be less susceptible to borer or beetle attack. This illustrates the value of matching seed source to site conditions. If drought is common, consideration should be given to using trees that originate from xeric sites.

Bur oak. Bur oak is a hardy, drought resistant, long-lived tree adapted to a wide range of growing conditions. It can be found on well drained upland sites or in damp lowland regions. Bur oak has not been widely utilized in the Northern Great Plains mainly due to the perception that the tree is slow growing and difficult to establish. The guiding principle for successful oak plantings may be to more closely match the species ecotype to the site.

In 1990, a bur oak seed source study was initiated. This study involved the cooperative efforts of 11 States and 3 Provinces in the North American Great Plains. The objectives of the study are: a) to determine the nature and extent of genetic variation among bur oak 'ecotypes' in the Great Plains, and to b) develop genetically improved seedlings that are adapted to the variety of site conditions present in the Great Plains.

The project involved the cooperation of foresters and resource specialists throughout the Great Plains. Selection of seed collection areas was based on the MLRA (Major Land Resource Areas) system as defined by the USDA, Soil Conservation Service (11). A total of 70 MLRA's that contain bur oak were sampled. Acorns from 207 individual trees were collected in 1991 and 1992. These seedlings have been propagated and planted in provenance tests at 16 sites from Texas north to Saskatchewan.

Conclusion

Tree improvement will continue to be an important activity at the Shelterbelt Centre. The sustainability of prairie tree plantings will depend on our ability to maintain the genetic diversity that is needed for healthy landscapes. It is important, especially with native plants, to work with the greatest degree of diversity possible, allowing us to maintain healthy populations that have the capacity to withstand the movement of disease or insects through a population of plants. This will require a continued commitment to the study of plant communities with less emphasis on individual specimens.

Literature Cited

1. Bagley, Walter. 1970. Tree improvement in Nebraska. A progress report. In Proceedings of the 22nd annual meeting, Great Plains Agricultural Council. June 23-25, Minot, North Dakota. pp.1-7.
2. Cram W.H. 1969. *Breeding and genetics of caragana.* For. Chron. 45(6):1-2.
3. Cram W.H. 1983. *Performance of seedling progenies of Picea pungens in southern Saskatchewan.* For. Chron. 59(3):146-147.
4. Cram, W.H. and C.G.E. Brack. 1953. *Performance of Scots pine races under prairie conditions.* For. Chron. 29(4):334-

342.
5. Cram, W.H. and C.H. Lindquist. 1971. Shelterbelt tree breeding. In Proceedings 13th meeting of the Canadian Tree Improvement Association. pp.102-106.
6. Lindquist, C.H., W.H. Cram, and J.A.G. Howe. 1977. *Walker poplar.* Can. J. Plant Sci. 57:1019.
7. Lindquist,C.H. and J.A.G. Howe. 1979. *Thomson elm.* Can. J. Plant Sci. 59:1159.
8. Looman, J. and K.F. Best. 1979. Budd's Flora of the Canadian Prairies. Research Branch, Agriculture Canada, Publication No. 1662. 863 pp.
9. Ross, N. 1923. Tree Planting Division, its history and work. Dept of Interior, Canada, Forestry Branch Report. 14 pp.
10. Schroeder, W.R. and L.K. Alspach. 1991. Soils Projects, pp 17-24. In PFRA Shelterbelt Annual Report, Agriculture Canada, Indian Head, Saskatchewan.
11. USDA, Soil Conservation Service. 1981. Land Resource Regions and Major Land Resource Areas of the United States. United States Department of Agriculture, Agric. Handbook No. 296. 156 pp.

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Résumé. La plantation de semis d'arbres et d'arbustes indigènes et le besoin en végétaux biologiquement et génétiquement diversifiés pour la plantation à grande échelle sont discutés. Les efforts de recherche en amélioration des arbres, spécifiquement avec le frêne de Pennsylvanmie et le chêne à gros fruits, au PFRA Shelterbelt Centre en Saskatchewan sont présentés.

Zusammenfassung. Das Pflanzen von aus Samen gezogenen einheimischen Bäumen und Sträuchern und der Bedarf an biologisch und genetisch unterschiediichen Pflanzen für selbsterhaltende Baumpflanzungen wird hier angesprochen. Es werden die Baumverbesserungsbemühungen, besonders mit der Grünen Esche und der Kletteneiche, durchgeführt von dem PFRA Schutzgürtel Zentrum in Saskatchewan beschrichen.