Tree Improvement
in British Columbia





Demand for wood products in Canada and worldwide remains high. Since we cannot produce more forest land, we must use the land we have to grow better trees at a faster rate. Renewing (regenerating) our forests with the best trees available makes environmental and economic sense.

A goal of tree improvement is to produce the best trees for reforestation in British Columbia. Tree improvement can increase the volume and value of future forests. Since 1955, tree breeders in British Columbia have worked to understand the patterns of genetic diversity for many tree species throughout coastal and interior ecosystems. This knowledge is then used to select, test, breed, and produce trees with increased wood volume and improved wood quality, and, in some species, to improve resistance to insects and diseases.





What is Tree Improvement?

Tree improvement is the process of selecting trees with desirable traits that will be passed on to their offspring – traits such as faster growth, straighter stems, better wood quality, and insect and disease resistance. It is also the process of producing seed from these desirable trees for reforestation. This results in a continuous cycle, one that includes selection, testing, breeding, and seed production.

Tree improvement has resulted in gains in growth rate from 3 to 30%, depending on the species and area of the province. These gains are achieved by selecting and testing the high-performing parents found in natural stands. In plantation forests, these gains result in stands that may be harvested sooner, and provide more wood of better quality. Increased wood production on managed forest lands enhances its economic value, and allows other forest lands to be reserved for other values.

Measurement of an interior lodgepole pine open-pollinated progeny test after five field seasons.

Cover images:

Gene archives and seed orchards at the Kalamalka Forestry Centre near Vernon.

Pioneering forest genetics research by Dr. Alan Orr-Ewing (shown) began in 1957, and contributes to modern programs.

How Tree Improvement is Done

Selection

In every forest a few trees stand out. Some are taller and straighter, some grow faster, and some have better wood quality or show resistance to certain insects or diseases. Sometimes these trees are growing on a better site, and sometimes there is something special about their genetics.

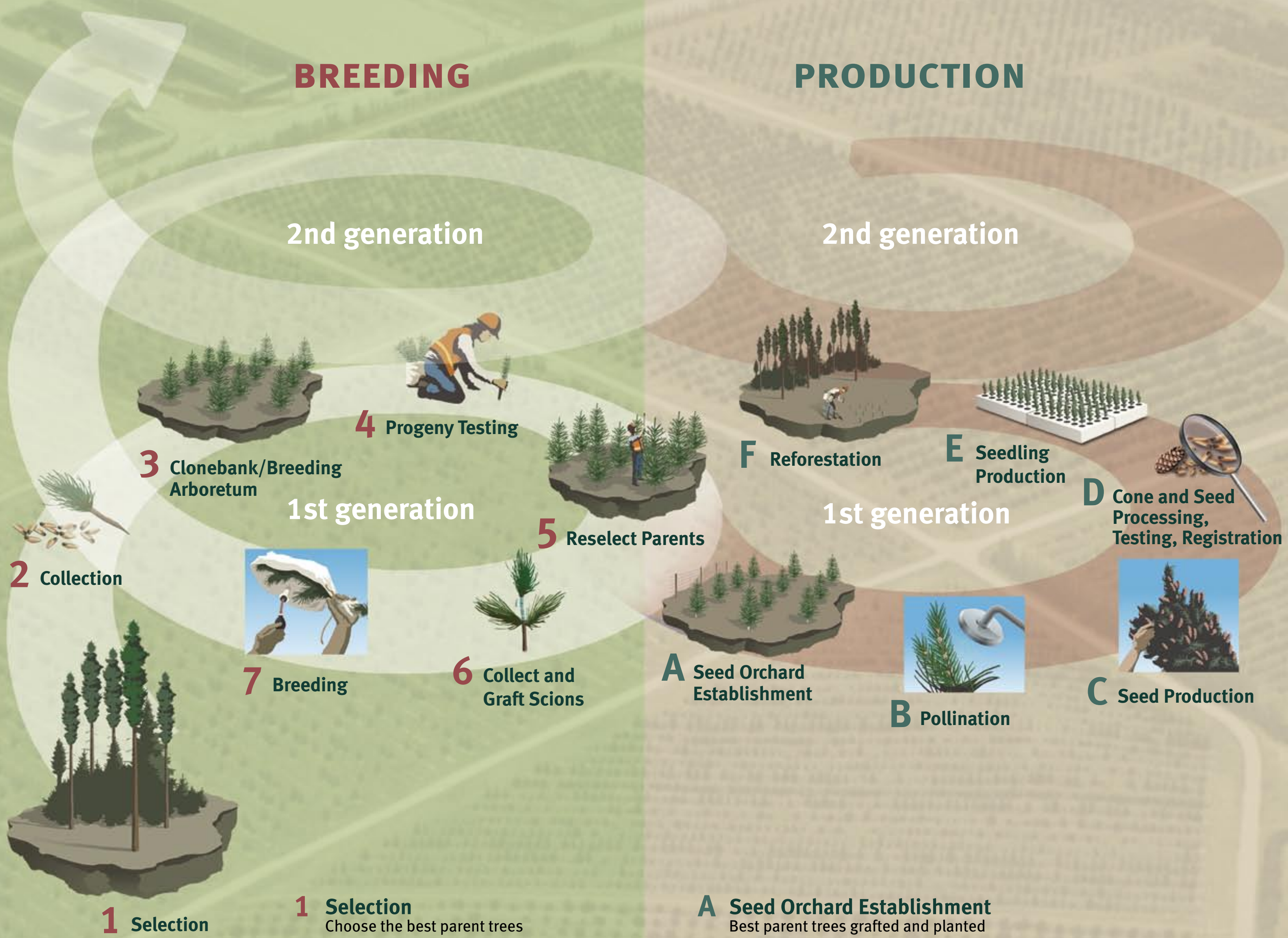
Tree breeders select parent trees in the wild that exhibit desirable traits, collect seed, and test the offspring on forest sites.

Testing

Seedlings grown from the seed of parent trees are evaluated for many years in forest plantations. This is known as progeny testing. Based on how the seedlings perform in the plantations, the *breeding value* of each parent tree can be determined. A *breeding value* predicts how well the seed from a tree will grow and perform for a specific trait such as stem volume, wood density, or resistance to a disease or insect.

Progeny testing must be done across many forest sites. These tests may take 5–15 years before useful results are obtained. Progeny tests generally continue for 25 years or more to allow the assessment of many traits and to ensure that the trees are exposed to the normal extremes of weather and pests.

Tree Improvement Cycle



1 Selection
Choose the best parent trees

2 Collection
Collect seed/scions

3 Clonebank/Breeding Arboretum
Graft scions to preserve genetic material

4 Progeny Testing
Grow and plant progeny of parent trees

5 Reselect Parents
Based on progeny performance

6 Collect and Graft Scions
From best-tested parents for seed orchards

7 Breeding
Controlled crossing among best parents for next generation

A Seed Orchard Establishment
Best parent trees grafted and planted

B Pollination
Supplemental pollination for seed production

C Seed Production
Collect cone crops

D Cone and Seed Processing, Testing, Registration
Cone and seed processing, testing, registration, storage, and pretreatment

E Seedling Production
Select orchard seed for seedling production

F Reforestation
Select seedlings used in reforestation

Developing cones of western larch.

Seed Production

Seed orchards are developed to produce seed from parent trees selected in breeding programs. A seed orchard is like a fruit orchard, with grafted trees (called ramets) planted in an area suitable for producing large cone crops. Unlike a fruit orchard, however, seed orchards have many different parent trees to ensure high levels of genetic diversity in the resulting seed crops.

Ramets in a seed orchard are grafted only from trees selected in breeding programs for desirable traits. Thus, seed produced in the orchard is of high genetic quality. Seedlings grown from orchard seed exhibit desirable traits, and are used in reforestation.

Seed orchards are developed for different geographic areas known as seed planning zones. This ensures genetic suitability to the climate and ecological conditions of the area in which seedlings are planted.

Breeding

Male cones produce pollen that is blown by the wind to female flowers. The female flower is pollinated, matures into a cone, and seeds develop within the cone.

Breeding begins with the isolation of female flowers before they are receptive to pollen. This is done by placing an isolation bag over the flowers, and sealing it to prevent the entry of any wind-borne pollen. Pollen is collected from the mature male cones on selected trees and is then applied to the isolated female flowers. When the seed from these crosses matures, new seedling families are grown from the controlled-cross seed and used for progeny testing and further selection.

There are active breeding programs for 10 species in British Columbia: coastal and interior Douglas-fir, western hemlock, Sitka spruce, western redcedar, yellow-cedar, interior spruce, lodgepole pine, western white pine, and western larch.

Controlled pollination of coastal Douglas-fir: pollen from a selected tree is injected into a pollination bag that isolates receptive female cones from wind-carried pollen.





Seed Transfer

Trees are genetically suitable to grow in certain climates and ecological conditions. For example, Douglas-fir from coastal British Columbia is not suitable for planting in the interior of the province.

Interior Douglas-fir from different geographic origins vary in their growth performance seven years after planting.

Why? Over thousands of years adaptation occurs through natural selection.

Scientists study the genetic differences between trees from various parts of a species' range. This is done by collecting seed from throughout the natural range of a species, and planting seedlings grown from this seed in research plantations called provenance tests. The provenance tests are evaluated over many years.

Provenance tests help reveal natural patterns of genetic diversity for each tree species. Based on these patterns, seed planning zones are determined, and seed transfer limits are established. Foresters follow these seed transfer limits so that genetically suitable seed sources are used for planting harvested areas.

In British Columbia, research on natural patterns of genetic diversity began in the late 1950s. Seed planning zones are currently defined based on patterns of genetic diversity and climate.

Gene Conservation

Forest managers recognize that conservation of the genetic resource of British Columbia's trees is very important. Two complementary strategies are being used to protect tree genetic resources. The first, *in situ* (in place) conservation relies on natural tree populations in parks, protected areas, and provincial forests. To ensure that adequate natural populations exist, gene resources are catalogued and any gaps are identified. The second strategy uses *ex situ* (out of place) collections such as seed collections and special reserves known as gene archives. *Ex situ* conservation also includes the network of progeny, and provenance tests established throughout British Columbia.

Fortunately, in British Columbia we have large natural populations of indigenous tree species. While these species are not threatened, some unique populations may be at risk.

An example of a conservation issue exists with whitebark pine. This non-commercial species is present at high elevations in the mountains of southern British Columbia. White pine blister rust is reducing whitebark pine populations, and scientists are concerned that the genetic resource is becoming threatened. Research is directed at understanding this problem and how to best maintain genetic diversity in this species.

This old whitebark pine tree near Whistler is infected with white pine blister rust, an introduced fungal disease that attacks all five-needled, soft pines. Selective breeding for resistance to this disease in western white pine has been underway in BC since 1985.

These coastal Douglas-fir trees are the same age and are from the same site. Genetics is the difference.

Forest Genetics Council of British Columbia

A co-ordinated and co-operative tree improvement program began in the 1960s with the Plus Tree Board, and continued with the Coastal and Interior Tree Improvement Councils.

Today, the Forest Genetics Council of British Columbia oversees many aspects of the tree improvement and the provincial gene resource management program. Council members represent the provincial government, forest industry, federal government, and universities, and are appointed by British Columbia's Chief Forester. Council advises the Chief Forester on gene conservation, tree breeding, seed production, and policy issues.

Council has a number of technical advisory committees with representatives from a broad spectrum of scientists, seed users, seed orchard managers, and operational foresters. The technical committees consist of representatives from the forest industry, Ministry of Forests and Range, Canadian Forest Service, and universities.

Forest Genetics Council Objectives

The following objectives are outlined in Council's Strategic Plan for 2004–2008:

- Increase the average volume gain of select seed used for Crown land reforestation to 20% by 2020
- Increase select seed use to 75% of provincial planting by 2013
- Support gene conservation research and the cataloguing of indigenous-tree genetic resources
- Co-ordinate stakeholder activities and secure resources to meet Business Plan objectives
- Monitor progress in gene resource management activities.

The Future

Rising populations in many countries are increasing the demand for wood products. At the same time, plantation forests throughout the world are creating a wood supply that competes with forest products from British Columbia.

In British Columbia, there is a clear demand for both an economically healthy forest industry, and stewardship of the forest resources. Tree improvement and gene resource management programs contribute to both of these objectives through conservation and through increasing the productivity of plantations.

Canada's major forest industry competitors (United States, New Zealand, Chile, Australia, and Brazil) all have intensive tree improvement programs to increase plantation productivity and quality. Moreover, many countries often utilize exotic species and biotechnology to further increase productivity. In British Columbia, where a strong land stewardship objective exists, we primarily rely on traditional breeding approaches. Therefore, to survive in an increasingly competitive global market, British Columbia must continue to be a leader in tree improvement. The sciences involved in forest genetics will provide the foundation of knowledge needed to address issues such as climate change, insect and disease resistance, and the use of biotechnologies in reforestation programs.

British Columbia's tree improvement program supports the increased volume and value of our future forests. Each year, over 200 million trees are planted throughout the province to replace trees that were harvested, destroyed by fire, or killed by insects and disease. The provincial tree improvement program helps foresters use only the best seedlings for planting our future forests.

Citation:
British Columbia Ministry of Forests and Range. 2005. Tree Improvement in British Columbia. B.C. Min. For. and Range and Forest Genetics Council of B.C., Victoria, B.C.
http://www.fgcouncil.bc.ca/brochure-tree-improve-05.pdf

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