Ministry of Forests, Lands and Natural Resource Operations

Climate-based seed transfer is critical to BC's forest economy in a changing climate – **Information Note, November 2016**

The Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) Tree Improvement Branch is leading the development of a Climate-Based Seed Transfer (CBST) system to support forest ecosystem resilience, health, and productivity in the face of a changing climate. The development of this project is in response to BC's Climate Leadership Plan and the Ministry's Climate Action Planning Initiative. CBST will also help achieve the Forest Genetic Council of BC's goal that "by 2020, the selection and transfer of all tree seed used to reforest crown land in BC will be guided by a climate-based seed transfer system that is regularly updated with new genecology and climate research information." [1]

This Information Note provides summary information on why BC is transitioning to a climate based seed transfer system and some insight on associated benefits and what to expect regarding anticipated impacts to the tree improvement and seed use community of practice.

CBST is an Important Silviculture Investment

CBST is an important silviculture investment to maintain forest ecosystem resilience, health, and productivity. The effect of climate change on timber supply is expected to intensify over time and to vary by region according to National Round Table on the Environment and the Economy. Projections have indicated that a reduction in timber supply from 8 to 14% by 2080 is possible for the province of British Columbia. [2] This reduction is mainly attributed to the impacts of wildfires and forest pests, as well as the loss of forest productivity.

Reflecting the economic importance of the forest sector to BC, projections also suggest that over the next century the cumulative cost of climate change could range from $5B to $32B[2]. Given that the rate of climate change is accelerating, and likely to exceed the ability of forests to effectively respond and adapt to new conditions, managed forest adaptation is required not only to reduce maladaptation, but also to maintain a competitive and sustainable forest sector. One approach to adapt to a changing climate and to ensure healthy, resilient and productive forests, and mitigate losses to future timber supply, is to reforest with tree species and seed that are genetically and ecologically suited to the new climate.

Why is climate-based seed transfer system needed?

BC's current geographically-based seed transfer system is relatively unchanged since the 1970s and does not mitigate the risk posed by a changing climate. The proposed CBST system is designed to match

Change in Average Temperature 1900 – 2013 in North, Central and Southern BC

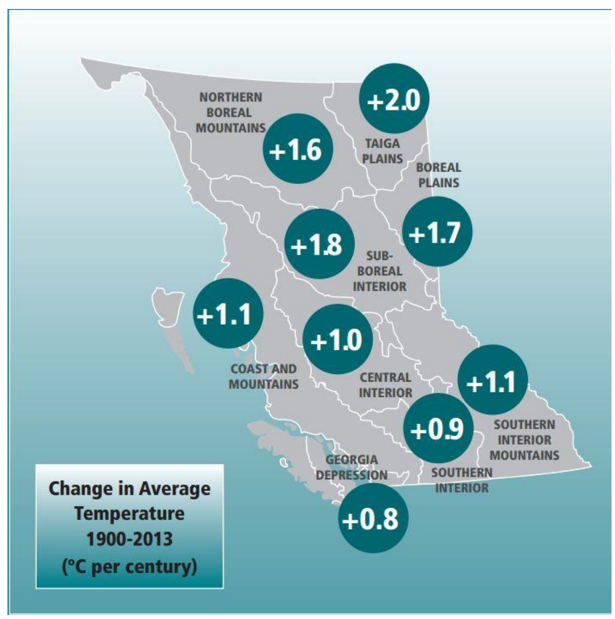


Photo image: Ministry of Environment, Indicators of Climate Change for British Columbia, 2015 Update

Objectives of a proposed climate-based seed transfer system[5]

- **Improve matching of seed sources with plantation climates** tree seed to what the climate will be like at the planting site inclusive of projected climate change (see objectives box).

- **Facilitate the use of assisted migration as a climate change adaptation strategy**
- **Increase seed use, flexibility, and deployability**
- **Reduce complexity through the use of common forest management platforms (e.g., BEC, Tree Species Selection and Stocking)**

Expected Impacts of Climate Change on BC's Forests [6,7]

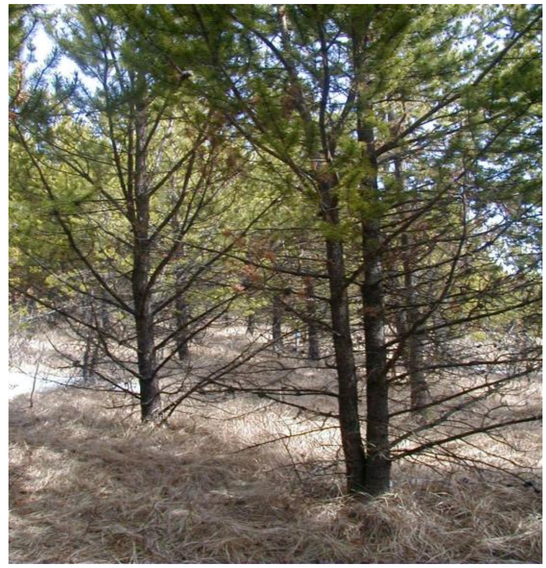
Coast	Southern Interior	Central Interior	Northern Interior
• Greater impacts in the southern dry ecosystems than the wet to very wet ones. • Increase in natural disturbance frequency, with drought and insect outbreaks more significant. • **Mortality of moisture sensitive species, such as western red cedar, is expected to continue**, but it may find a more productive niche as it expands in elevation. • **Western hemlock may be impacted if moisture becomes limiting.** • **Coastal Douglas-fir has the potential to expand its range northwards along the coast and upslope.** • Lowland coastal temperate forests could undergo significant losses because some dominant species, such **as Douglas-fir & western hemlock, might not receive sufficient chilling to induce cold-hardiness and would then suffer serious damage from recurring frost**. • Higher elevation coastal forests would generally benefit from longer growing seasons stimulating higher productivity.	• Complex series of effects are projected for this area. • Increased frequency of fire; biological threshold of some species exceeded; influx of new species; contraction & expansion of some species ranges. • Species like **lodgepole pine are projected to lose out at lower elevations, but gain at higher** • Upper elevation species, such **as subalpine fir and spruce, are projected to be gradually replaced by Douglas-fir and western larch** • Douglas-fir forests projected to remain substantially unchanged, with **possible increase in drought-tolerant Ponderosa pine.** • ICH zone expected to expand upwards and northwards into the ESSF along with components of Douglas-fir. • **Western larch is expected to undergo a large geographic expansion.**	• Lower elevation ecosystems are expected to expand while higher ecosystems will become highly stressed. • In some ecosystems there is the potential for a **large decrease in lodgepole pine and increased frequency of Douglas-fir** as both temperature and precipitation increases. • Northwards, hybrid spruce and subalpine fir are expected to continue to be important species on the landscape although **interior spruce is vulnerable on dry sites due to moisture stress** • **Douglas-fir projected to eventually dominate the terrain due** to reduced severity of growing season frost, and a significant increase in the length of its growing season. • Outbreaks of insects and diseases in both conifers and deciduous species is expected to increase especially in areas of moisture stress.	• Lower elevation ecosystems are expected to expand while higher ecosystems will become highly stressed. • Boreal forest structure and composition dynamics projected to dramatically alter in structure and composition. • Fire frequency and severity expected to increase. • Results of increased fire frequency means greater proportion of grassland and younger forests on landscape • Mixedwood tree species such as trembling aspen and white spruce are expected to continue as prominent components of future forests • **Interior spruce on dry sites may be vulnerable.** • Decreased moisture and increased occurrence of late season drought will lead to decreased reforestation success and tree mortality. • Outbreaks of insects and diseases in both conifers and deciduous species is expected to increase especially in areas of moisture stress.

Climate Based Seed Transfer
Supports Healthy, Resilient, and Productive Forests in a Changing Climate

Climate Change is Impacting BC's Forests and Ecosystems

Climate change is impacting BC's forests and ecosystems in a variety of ways. These impacts are due to the increased frequency and intensity of fire, drought, insects, diseases, and flooding[6,7]. Physiological processes such as growth rate, drought resistance, cold hardiness and the timing of physiological processes will become less optimized for native tree species and populations. This will manifest as increased damage from pest outbreaks, poorer growth, higher rates of mortality from drought and cold events, and other impacts that reduce forest health and productivity[4].

Expected impacts of climate change on BC's forests (further defined in the table, *Expected Impacts of Climate Change on BC's Forests,* located on the previous page) highlight the necessity to develop a climate-based seed transfer system that will mitigate productivity losses and improve genetic adaptation.



Maladaptation of trees planted in the wrong climatic condition

Assisted Migration is a Climate Change Adaptation Strategy

Rational for updating the system now

Significant opportunities to improve BC's seed transfer system and to enhance the resiliency, health, and productivity of BC's forests and forest ecosystems exist now.

These include[5]:

- The urgency to take action against climate change impacts;
- Recent advances in genecology research methods;
- Availability of an extensive and expanding network of climate-relevant science, data and knowledge;
- New data from old and new provenance trials;
- Refinement of GIS and fine-scale climate models;
- Improved General Circulation Models (GCMs) and a world class made-in-BC climate model (Climate WNA)[8];
- New genomic tools capable of assessing seed source

Assisted Migration[5]

A climate change adaptation strategy that involves the intentional movement of tree seed, from areas they grow naturally, to planting sites that are climatically suitable for their growth at the present time, and into the future.

Assisted Population Migration is a climate change adaptation strategy aimed at moving tree seed within the species natural range

Assisted Range Migration (or Expansion) is a climate change adaptation strategy that is aimed at moving tree species outside their natural range.

These strategies are being analyzed for potential application in the new CBST policy.

suitability and climate adaptation; and

- The inclusion of Assisted Migration as an appropriate forest management strategy to address climate change (see box as to how Assisted Migration is defined under CBST).

These advances provide an opportunity to accelerate the adaptation of forests to climate change and to foster a positive impact on forest health and productivity; and, on access to future timber supply, forest carbon and fibre resources, and other ecosystem services, provided by BC's provincial forest[3].

What are the implications of a climate based seed transfer system?

CBST will provide opportunities for optimizing forest productivity in a changing climate while minimizing reforestation risk. Costs to transition and fully implement CBST include adjustments to seed inventories, breeding programs, and seed orchards, as well as re-tooling information management systems. Analysis indicates a positive benefit-to-cost ratio[3] (see graph below).

Figure: Benefit-to-cost ratios for a range of average productivity losses in provincial forests due to climate change and a range of levels of mitigation of these losses due to improved genetic adaptation under CBST. These scenarios were run over a 100 year period from present using a 3% social discount rate and an assumed annual CBST research cost of $2.5 million per year.

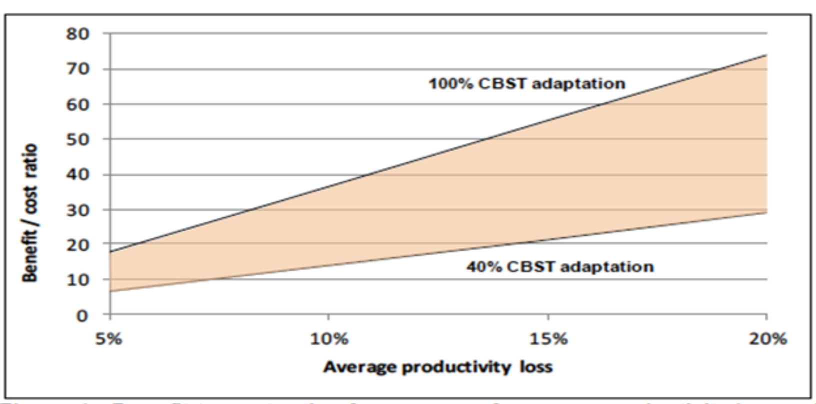
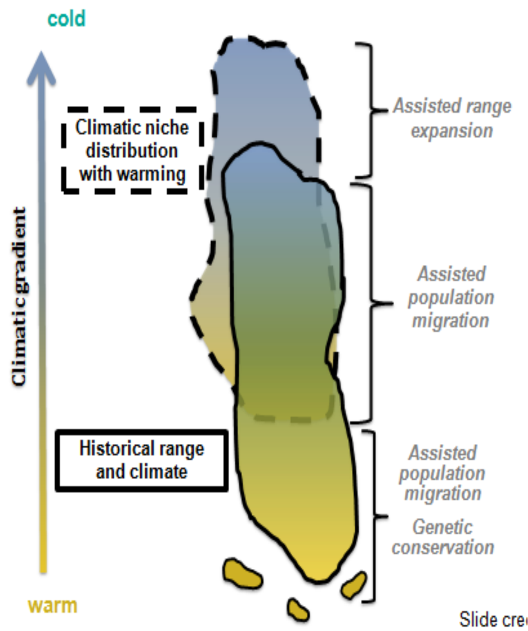


Image credit, Jack Woods

Schematic of Assisted Range Expansion, Population Migration (within a range) across historical and future climate envelopes.



The need for adaptive policy, monitoring, and ongoing research

Managing forests successfully in a changing climate presents new challenges in the form of increased risks and uncertainties. With CBST, FLNRO is pursuing new policies that foster flexibility (e.g. increase seed deployment), mitigate risk (e.g., through identifying genetic suitability thresholds appropriate for a changing climate), balance trade-offs (costs/benefits), and provide a greater likelihood that seed choices will continue to sustain forest productivity and forest ecosystem services over the long term.

To ensure that a new CBST policy reflects the realized changes in climate a successful CBST system will include monitoring, continuous improvement, and periodic updates of foundational data sets (e.g. BEC, genetic suitability transfer functions) and climate modelling. Ongoing scientific research is also needed to evaluate and model climate-change impacts at more refined scales, maintaining genecology research to better understand how climate are changing and what impacts they will have on seed-source choices and pest impacts at the local scale. In addition, emerging technologies like genomics will be better linked with field-based research to inform seed transfer policies and reduce transfer risk.

Climate Based Seed Transfer
is a project identified in the
BC FLNRO Forest Stewardship Climate Action Plan

SUMMARY

Climate change continues to increase the frequency and impact of wildfires, forest pests and diseases, droughts, and extreme weather events, leaving BC's forests and forest dependent communities more vulnerable. Climate change is also causing the populations and ranges of BC tree species to expand in some locations and retract in others.

- A Climate-Based Seed Transfer system is being developed to address environmental changes and, to implement assisted migration as a climate change adaptation strategy.
- Climate-Based Seed Transfer will help to support a competitive and sustainable forest sector as well as genetically diverse, healthy, and resilient forests.
- There will be some business implications with implementation of this new system, but the costs are estimated to be relatively small compared to the climate change impacts that CBST will address and the cost of doing nothing.
- Forest geneticists are working together to identify seed sources with increased pest resistance as additional strategies for addressing secondary climate change impacts.
- The new CBST policy will need to be adaptive and responsive to climate as it changes. This means new scientific information will continually inform policy updates.

Ministry of Forests, Lands and Natural Resource Operations

In 2015 (seedlings ordered for the 2016 sowing request year), the BC Ministry of Forests, Lands and Natural Resource Operations ordered 255M seedlings for Crown land reforestation.

Through the ministry's Land Based Investment Strategy and Tree Improvement program, BC invests in forestry-related tree improvement, seed transfer and climate change adaptation projects.

For more information on CBST go to:
www.gov.bc.ca/climatebasedseedtransfer

http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/seed-planning-use/climate-based-seed-transfer

For queries regarding the CBST project, contact:
Margot Spence, CBST project manager (Margot.Spence@gov.bc.ca

1. Forest Genetics Council of British Columbia Strategic Plan 2015-2020. 2015. Forest Genetics Council of BC Publication.

2. Canada National Round Table on the Environment and the Economy. (2011). Paying the Price: The Economic Impacts of Climate Change for Canada.

3. Woods, J and C. Mahoney, 2016 Climate-Based Seed Transfer: Guiding British Columbia's reforestation investments in a changing climate. Forest Genetics Council of BC Technical Extension Note. http://www.fgcouncil.bc.ca/CBST-investment-extension-note-FINAL.pdf

4. Aitken S. N., Yeaman S., Holliday J. A., Wang T. & Curtis-McLane S. Adaptation, migration or extirpation: climate change outcomes for tree populations. Evol Appl 1, 95–111 (2008).

5. O'Neill, G., T. Wang, N. Ukrainetz, L. Charleson, L. McAuley, M. Stoehr, A. Yanchuk, and S. Zedel. 2016. A Proposed Climate-based Seed Transfer System for British Columbia. MFLNRO Technical Report (unpublished)

6. Swift, K. & Ran, S. 2012. Successional Response to Natural Disturbance, Forest Management, and Climate Change in British Columbia Forests. BC Journal of Ecosystems and Management 13(1): 40-62

7. Ministry of Forest, Lands and Natural Resource Operations. 2016. Adapting forest and range management to climate change – Regional Extension Note Series – Considerations for Planners and Practitioners. (6 Regional Notes)

8. Wang, T.L., A. Hamann, D.L. Spittlehouse, and T.Q. Murdock. 2013. Climate WNA: High-Resolution Spatial Climate Data for Western North America. Bulletin of the American Meteorological Society. Pp 1307-1309