Responding to Climate Change: Assisting seedlot migration to maximize adaptation of future forest plantations

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Summary

Little is currently known regarding the adaptive responses of breeding populations of BC's commercially important tree species. To ensure that each reforestation site receives the Class A seedlots that are best adapted and most productive for its current and future climate, each breeding/production population must be tested across a broad range of climatic and latitudinal environments.

The Assisted Migration Adaptation Trial (AMAT) intends to test the 35 breeding/ production populations (i.e., Class A seed orchard seedlots for which seed is available, from BC and western States) across 48 test sites. Twelve field tests per year for each of four years will be established throughout BC and neighbouring states, beginning in spring 2009. Use of local control (wild stand) seedlots and a block plot layout will enable realized genetic gains to be estimated for each population. Productivity of each population will be described as a function of the climate and latitude of the test sites, enabling development of a deployment system that will maximize forest productivity while ensuring the widest deployability of every orchard seedlot.

Background

Identifying the seedlots that are best adapted to a reforestation site can be one of the most important reforestation decisions (Zobel and Talbert 1984). However, in many areas of the province, seedlots that are adapted today will be rendered maladapted toward the end of their rotation by climate change, resulting in decreased pest resistance, growth and wood quality. Planting seedlots adapted to a longer portion of their rotation (i.e., assisted migration) is recognized as a cornerstone strategy to mitigate negative impacts associated with climate change (Ledig and Kitzmiller 1992; Carter 1996; Rehfeldt et al. 2001; Rehfeldt 2004; Sonesson 2004; Wang et al. 2006), and in some cases may enhance a site's productivity in a warmer climate (Rehfeldt et al. 2001).

Approximately 50% of all seed planted in the province originates from seed orchards (i.e., Class A seed). By 2013, approximately 75% of planted seed is expected to be Class A seed (see Business Plan of the Forest Genetics Council of BC at http://www.fgcouncil.bc.ca/). The majority of the progeny tests used to evaluate orchard parent trees were established when climate change was not perceived as a significant issue, and the need to move seed large geographic distances to ensure adaptation of planted seed was not envisaged. Consequently, the vast majority of orchard parent trees have been tested only within a narrow climatic and latitudinal range and only within the breeding zone from which they originated.

Heightened calls for assisted migration and increased species diversity associated with climate change and replanting beetle-infested areas are creating a demand for Class A seed outside of each seedlot's tested environment. Testing of species outside of their current range shows that populations of some species perform remarkably well where they are not currently native, as evidenced by multi-species testing in the Bulkley Valley (Barry Jaquish, pers. comm.) and in the Cariboo (Koot 2007) (see http://www.for.gov.bc.ca/hfd/library/FIA/2007/LBIPI_4638002a.pdf). Without better understanding of their productivity, wood quality, and health responses across a wide climatic and latitudinal range, it is difficult to predict which class A seedlots are most suitable for current or future climates (Fig. 1).

Project focus

Climate change inserts a new dimension into seedlot selection because the best adapted species and seedlots for a site will likely change during the rotation. Identifying the best adapted seedlots will therefore involve maximizing adaptation (the seedlot–climate match) over the course of the rotation.

The primary focus of this project, therefore, will be **to develop an understanding of the adaptation of each breeding population**, as

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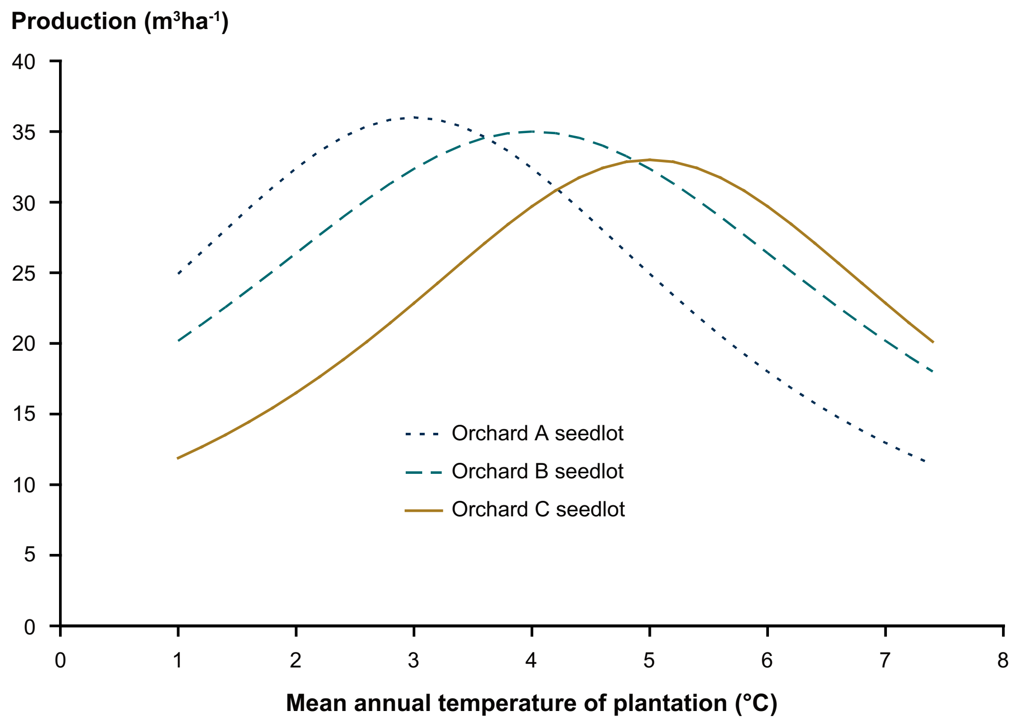

Figure 1. This schematic shows possible response functions of three seed orchard seedlots. Knowledge of response functions such as these could help identify seedlots expected to be best adapted and most productive in each climate.

The primary focus of this project, therefore, will be to develop an understanding of the adaptation of each breeding population, as represented by class A seedlots or seed from elite families, across a range of climatic and latitudinal environments in BC and adjacent states.

represented by class A seedlots or seed from elite families, across a range of climatic and latitudinal environments in BC and adjacent states. Knowledge of the adaptive response of each seedlot to a range key climatic variables and photoperiod (latitude) will form the foundation of a system of assisted migration of seed that will help mitigate maladaptive responses in some areas, while potentially enhancing forest productivity in other areas (Wang et al. 2006), and ensure that the gains achieved through four decades of tree breeding in BC will be realized in a future climate.

Second, local wildstand controls planted at each test site will enable the growth of each breeding/production population to be compared to that of wildstand seed, and a **realized genetic gain to be calculated for each breeding/production population, and estimated for all climates**. Use of large block plots will minimize competition among plots of each population, thereby minimizing inter-seedlot competition and improving the accuracy of the realized gain estimates.

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An extensive set of Class A seedlot tests is required across a diverse array of climatic and latitudinal environments. By relating test site climate and latitude to productivity, wood quality and health of each Class A seedlot (Fig. 2), those species and seedlots that will maximize these attributes of BC's forests across the climates of a future rotation can be identified, and this information incorporated into species and seedlot selection systems.

The proposed project addresses critical knowledge gaps in our understanding of the growth of genetically improved seedlots across a range of climates and latitudes. Specifically, the experiment seeks to:

1. quantify the productivity of BC's genetically improved populations across a wide climatic and latitudinal range in order to estimate their performance in current and new environments (i.e., develop response functions);
2. compare productivity of A and B class seed and calculate realized genetic gain; and
3. incorporate knowledge of class A seedlot (breeding population) productivity into species and seedlot selection systems.

Project design and implementation

For each of the 35 Seed Planning Units that currently have orchard seedlots, one seedlot will be solicited from seedlot owners. These seedlots, along with local controls consisting of pooled wildstand seedlots, will be tested in an incomplete design at 48 locations, with each orchard seedlot planted at approximately 30 locations. The large number of locations, relative to typical progeny tests, and their careful selection is required in order to adequately sample the climate space of each species' fundamental niche and to develop growth response equations using multiple site climate variables.

To ensure that the test sites sample the range of climates found in BC, the 192 forested biogeoclimatic variants were clustered into 48 groups, with each group representing somewhat similar climates. Twelve field tests per year for each of four years will be established throughout BC and neighbouring states, beginning in spring 2009. Research Branch staff will be contacting licencees in central and Southern Interior BC (the location of the first 12 sites) to request assistance identifying candidate field test sites and donating seed to this important project.

Height, diameter and survival will be measured on all trees at five-year intervals. Seedlot growth statistics will be input into TASS, and expected volume at rotation estimated for each seedlot at each site. Volume at rotation of each species will also be expressed as a percent of the local control seedlot to calculate realized gain of each seedlot. Response functions will be developed relating rotation-age volume of each seedlot to the climate and latitude of test sites, and maps developed to identify the most productive seedlots for each climate.

Numerous individuals have provided input on the design of this project. Anyone wishing to receive the complete project proposal should contact Greg O'Neill (greg.oneill@gov.bc.ca) or Michael Carlson (michael.carlson@gov.bc.ca). Continued feedback is appreciated.

Start-up funding for this project was received from the Forest Genetics Council. This project has been identified as a key project of the Future Forest Ecosystem Initiative.

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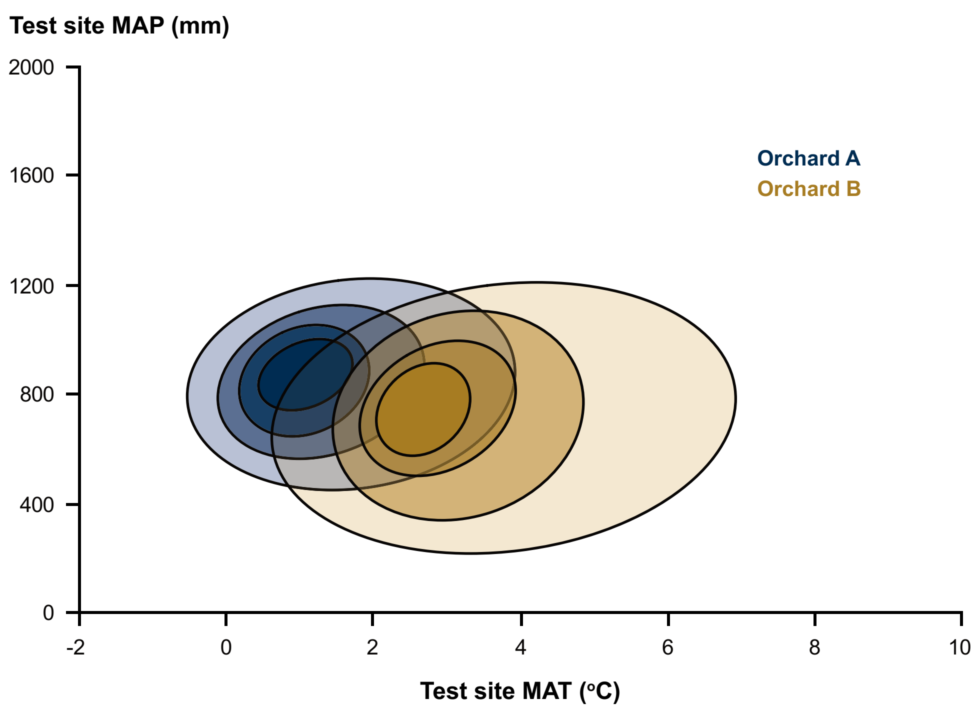

Figure 2. Example of possible genetic worth clines of two seed orchards seedlots based on two climate variables. Knowledge of such GW clines could alter seedlot selection decisions and improve adaptation and productivity of plantations. In addition, GW clines would greatly improve the ability to make informed decisions regarding assisted migration of species and seedlots.

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