Proposed research on social perception of marker-assisted selection and its role in the forests of British Columbia

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ABSTRACT

The forest industry is a major player in the provincial economy, provides a significant contribution to government revenue, and accounts for 3% of British Columbia's GDP. However, with the reduction of housing starts in the US in 2006, the economic crisis of 2008, a steady decline in newsprint demand, and the Mountain Pine Beetle epidemic, the provincial and federal governments have searched for ways to help transform the forest industry through innovation, improved environmental performance, and new markets. One such investment has been in marker-assisted selection (MAS), which is a genomic-based biotechnological tool that allows desired traits to be flagged on the genome. Since MAS is a new genomic tool to the forest industry, it is necessary to survey silviculture stakeholders in BC on their perception of this resource to tree breeders, its perceived use, and the context for which it should be implemented. If it is a tool whose implementation is perceived positively, it would significantly reduce the cycle of the tree breeding process, as it allows for the early selection of genotypic traits. Moreover, it would allow tree breeders to more efficiently and accurately select for improved wood qualities, growth rates, and resistance to pests, diseases, and climate change.

Keywords: marker-assisted selection, perception, social perception, genomics, biotechnology, forestry

RÉSUMÉ

L'industrie forestière est un secteur important de l'économie provinciale, représente une source significative de revenus gouvernementaux et totalise 3% du PIB de la Colombie-Britannique. Cependant, suite au déclin du nombre de mises en chantier de maison aux États-Unis en 2006, suite à la crise économique de 2008, suite à une diminution constante de la demande de papier journal et à cause de l'épidémie de dendroctone du pin, les gouvernements provincial et fédéral ont cherché des moyens d'aider à transformer l'industrie forestière par des innovations, par l'amélioration de la performance environnementale et de nouveaux marchés. L'un de ces moyens a été la sélection à l'aide de marqueur (SAM), un outil biotechnologique basé sur la génomique qui permet d'identifier dans le génome des caractéristiques désirées. Compte tenu que la SAM est un nouvel outil génomique dans le milieu de l'industrie forestière, il faut effectuer un sondage auprès des intervenants en sylviculture de la C.-B. pour pouvoir décrire leur perception de cet outil auprès des pépiniéristes, son utilisation envisagée et le contexte selon lequel elle pourrait être implantée. S'il s'agit d'un outil dont l'implantation est perçue positivement, cela permettrait de raccourcir significativement le cycle du processus d'amélioration génétique, compte tenu qu'il permet une sélection hâtive des caractéristiques génotypiques. De plus, cela permettrait aux pépiniéristes de choisir avec plus d'efficacité et de précision des spécimens démontrant des qualités ligneuses, des taux de croissance et de résistance aux ravageurs, aux maladies et aux changements climatiques plus intéressants.

Mots clés : sélection à l'aide de marqueur, perception, perception sociale, génomique, biotechnologie, foresterie

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Introduction

The iconic forests of Canada embody 39% of the land base, and comprise 10% of the world's forests (NRCan 2013). With a historically active forest sector, the forest industry contributes approximately \$18.7 billion to the country's economy, is the world's leading exporter of softwood lumber, newsprint, and pulp, and the second largest exporter of primary

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forest products (NRCan 2013, 2014a, 2014b; Rank 2013). The forest industry is likewise a major player to British Columbia's economy, providing a significant contribution to government revenue, and accounting for 3% of the province's GDP (Council of Forest Industries 2014). Though traditionally cyclic yet stable in nature, the forest industry experienced a significant decline in GDP between 2005 to 2009 resulting from a reduction in housing starts in the U.S., a shift away from newsprint, and the economic recession of 2009 (NRCan 2013). The forest sector has since stabilized with an improving U.S. housing sector, increased domestic demand, and continued growth in the Asian market (NRCan 2013). As such, the government has invested in federal programs to support the transformation of this sector through innovation, improved environmental performance and an expanded market (NRCan 2013). Over the last decade, Canada has invested over \$90 million in forest genomics research to improve forest productivity and protect the health of the forest (Rank 2013).

SMarTForests (Spruce Marker Technologies for Sustainable Forestry) is a partnered project between the University of British Columbia, the University of Alberta, and Université Laval, and is funded by Genome Canada, Genome Quebec, Genome British Columbia, and Genome Alberta. By drawing on the findings from previous research projects, such as Arborea and Treenomix, the SMarTForests Project will sequence the white spruce genome, develop marker systems, and analyze the impacts of forest genomics (Smart Forests 2012b). The white spruce (*Picea glauca* [Moench] Voss) is an important species in Canada, accounting for nearly 60% of the tree seedlings planted each year. This research will link with other conifer genome sequencing projects in Sweden, the USA, and Europe (Smart Forests 2012b). Within Canada, these research approaches will be transferred to black spruce to support genomic applications in the boreal forests (Smart Forests 2012a).

Spruce trees have been identified as the ideal species to target for genomic research for environmental and economic benefits since over 650 million seedlings are planted each year in Canada (Smart Forests 2012b). Specifically, with increased market competitiveness, the reduced contribution to GDP, pest and disease outbreaks, and the crucial role of healthy forests to the carbon cycle, the Canadian forest sector is looking at long-term investments and strategies to ensure the survival of a key pillar of the Canadian culture (Rank 2013). Genomics offers a tool to improve the productivity and health of forests. Distinctly, the SMarTForests Project has focused on the development of diagnostic markers to achieve this goal.

Marker-assisted selection (MAS) is a branch of biotechnology and serves as an information tool that allows specific traits to be marked on the genome (Brumlop and Finckh 2011). Through a flagging process, MAS identifies whether desired traits are found in the DNA of a collected sample. This innovative tool will allow tree breeders to identify genotypic characteristics of an individual at the seedling stage, whereas traditional tree breeding methods require a tree to reach maturity (approximately age 30) for these same traits to be identified (Nienstaedt and Zasada n.d.). MAS will not only save decades of time from a breeding perspective, but it could also allow the early detection of key traits such as resistance to pests, diseases, and drought, wood density, wood quality, and carbon storage. Moreover, free of any DNA manipulation (a characteristic of genetically modified organisms), MAS would

be a tool used in natural offspring inheritance. MAS would enable the identification of specific traits in seedlings grown from seeds collected from trees in the existing forest. It would inform breeders which genotypic traits these seedlings are expected to exhibit as mature trees, and thus speed up the process of natural selection.

Of the 95 million hectares of land that comprises British Columbia, 55 million hectares (approximately 60%) is forested land. Of this forested land, 95% is publically owned (94% provincially and 1% federally; Ministry of Forests, Mines and Lands 2010). With steady demand and globally changing climate, there has been increasing concern for the future of BC's forests. Warming temperatures have increased the incidence of drought, forest fires, pests and diseases (Filmon 2003, LiveSmart BC 2013). The Mountain Pine Beetle (*Dendroctonus ponderosae*) has killed over 710 million cubic meters of timber ranging over 18.1 million hectares of BC forest (Government of British Columbia 2012). The government has been working to address the decreased mid-term timber supply, and the future health and sustainability of the forest. MAS is an innovative tool that could assist tree breeders in selecting seeds, assuring that the forests of BC are restocked with the most resilient seedlings.

Since the majority of BC's forests are publically owned, it will be necessary for a biotechnological tool like MAS to have stakeholder and public support for it to be successfully implemented. In Canada, it is prohibited to use genetically modified trees on Crown lands; however, there are no provincial or federal regulations or policies that specifically prohibit the use of MAS (Research and Knowledge Management Branch 2010). So although MAS is a distinctly different branch of biotechnology, it will be essential that forest stakeholders recognize this difference in order for the tool to be accepted.

The aim of this research project is to survey silviculture stakeholders in BC to determine their perception on the potential future use of MAS on BC's public forested lands, and identify if that perception is dependent on the context of implementation. It is hypothesized that stakeholders would be supportive of this tool if: it provides significant genetic gains and is thus economically beneficial; it provides seeds that are significantly superior from a risk-reducing perspective (e.g., resistant to pests, diseases, drought); and/or it provides trees with improved wood quality and volume without any genetic modification.

Methods

We will begin this research project by seeking ethical approval for our project. All research that involves human participants must be first reviewed and approved by the Behavioural Research Ethics Board (BREB) at the University of British Columbia. Before recruitment or interaction with participants takes place, it is required that BREB reviews the research proposal, all consent forms, interview guides, letters of initial contact, and questionnaires that are designed for the study. It is also necessary that all researchers have completed the self-paced Course on Research Ethics (CORE), which ensures that researchers have reviewed and will adhere to the Tri-Council Policy Statement 2.

Once BREB approval is attained, we will begin contacting participants. We will seek participants that have a stake in silvicultural practices in BC. It is expected that we will target key

individuals from government, the forest industry, environmental non-governmental organizations, and First Nations. It is important that our sample is highly knowledgeable and well represented, so it will be necessary to connect with individuals from both the coast and interior of the province that work in key forest-related areas.

In preparation for the interviews, it will be necessary to develop an interview guide that ensures our research objectives are being met. In this case, we plan to use a mixed-methods approach, by developing semi-structured, open-ended qualitative interview questions, and a quantitative questionnaire. For the interviews, we have elected to perform individual interviews over focus groups. Although focus groups have been known to be more common, logistically flexible, and cost-effective, Fern (1982) found that individual interviews produced significantly more ideas than focus groups of four or eight members (Morgan 1996). We aim to complete 20 to 25 individual interviews, which is consistent with the standard sample size deemed appropriate to achieve data saturation of themes in qualitative studies (15 to 20; Samure and Given 2008).

For the quantitative questionnaires, we will develop a Likert scale questionnaire so that participants can rank their level of agreement or value to the statements provided. They will complete these questionnaires following their interview.

Once the interview guide and questionnaire are developed, we will perform pre-tests to ensure that the questions are adequate, relevant, and clear. We will test these surveys on individuals from similar groups or organizations to those of our targeted participants. It will also be necessary to ensure that they are void of bias and directionality, and evoke responses that meet the objectives of the study.

In preparation for the interviews, it is also expected that participants will be unfamiliar with MAS as it is a new biotechnological tool to the forest industry. We will present participants with a brief educational package, consisting of an 11-minute video, before they share their perceptions of MAS. This video was originally prepared by Télé-Québec and aired on the scientific series, *Le Code Chasténay*, in January 2008. This video informs the audience on the current struggles with the forest industry in Canada, explains what MAS is and how it can be used, and some potential implications of the technology. Since the interviews will take place in BC we have assumed that participants' primary work language is English, so we have sought permission from the broadcast agency to apply English overlays to the video, as long as the material is translated verbatim.

Once the interview stage of the project begins, we will coordinate and schedule interview times with participants at their place of work. The interviewer will review the consent form with the participant before addressing the interview questions. The participant will also be asked to sign a consent form for audio recording. The participants will be invited to share their background experience in the forest sector, previous knowledge on genomics and tree breeding, and discuss their first impressions of MAS. They will also be asked to share their attitudes, perceived benefits and costs, and the foreseen potential uses of MAS in the forest industry in BC. Since the interviews will take a semi-structured, open-ended format, it is anticipated that each interview will take the form of a relaxed conversation, and will take about an hour to complete.

Upon the completion of the interview stage, we will review and transcribe each interview verbatim using the NVivo 10 software package. Once the transcription is completed, we will systematically code for themes to elicit trends that emerged. The findings from the interviews will be compared against the quantitative data derived from the questionnaires.

Application of Results

It is expected that the proposed research will inform the potential place and role of MAS in the forest industry of BC. Through this investigation, the perceived benefits, costs, and hindrances to implementation will be identified. It is expected that the results derived will provide a lens into the desired context of implementation. This will be crucial to forest genomic programs that are being developed not only in BC, but in Canada and internationally. Once informed on which traits are most desired by silviculture stakeholders in the forest industry, geneticists can focus their attention on locating those traits on the genome and performing trial experiments.

The results of this study will also contribute to the limited knowledge that exists of social perception on genomic technologies in forestry. By investigating the social, economic, and environmental concerns around the responsible implementation of this tool, this project will identify the barriers and opportunities for its deployment. This will bridge the gap that often exists between a wet lab and tools that reach the workplace.

If this tool is perceived positively, its application could greatly improve the health and productivity of BC's forest. It is anticipated that stakeholders will value its ability to select for improved wood qualities, growth rates, and resistance to pests, diseases, and climate change (Smart Forests 2012b). MAS would drastically reduce the time required between generations compared to traditional tree breeding methods. And most importantly to the forest industry, selection of these traits could improve the overall efficiency, resilience, and value of the forest (Smart Forests 2012b).

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