Opinions on strategies for forest adaptation to future climate conditions in Western Canada: Surveys of the general public and leaders of forest-dependent communities

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ABSTRACT

Two province-wide surveys of residents in Alberta and British Columbia were conducted to assess the acceptability of a range of reforestation strategies — many of which revolve around biotechnology — that could be used to aid Western Canada's forests in adapting to future climate change. The opinions of leaders of forest-dependent communities were also sought to evaluate how well they align with those of the public-at-large. Results show that the general publics' and community leaders' views correspond. There is a low acceptance for a 'do nothing' strategy that allows climate change to run its course without any human intervention, high acceptance of replanting with local seeds, a decreasing acceptance of strategies that involve more manipulation such as breeding, using non-local seeds, and moving seeds outside of a species' natural range, and a low acceptance of genetically-engineered solutions. However, a high proportion of respondents changed their answers when told that a particular strategy would lead to either favourable or unfavourable outcomes related to socio-economics of forest-dependent communities, forest aesthetics, and pest, disease, and fire outbreaks. We conclude that a meaningful and participatory dialogue on forest adaptation strategies in the face of climate change can only emerge if residents and other interested stakeholders have an adequate understanding of current forest management practices, proposed reforestation strategies, the role of technological interventions, and the values and services for which Western Canada's forests are to be managed.

INTRODUCTION

The critical roles that forest ecosystems play around the world cannot be overstated. From the provision of goods and services demanded by society, to the regulation of climatic and hydrologic cycles, to the countless biodiversity and genetic resources contained within them, the future vitality of forests is inextricably linked to the future health of our planet. This is certainly true for the highly forested western Canadian

provinces of Alberta and British Columbia, where forestry plays a prominent role in generating provincial revenues, providing meaningful forest-based employment, and sustaining rural communities. Despite recent challenges revolving around stagnant economic conditions and the housing crisis of 2008, the mountain pine beetle infestation, the unrelenting wave of globalization and the associated emergence of low-cost timber producers from all over the world, forestry, in many ways, remains an 'economic engine' of these provinces. A key export sector in both provinces, forest-based activities continue to provide direct employment to nearly 100,000 people in dozens of communities, and are a major source of tax revenues to governments, especially at the provincial level (Alberta Forest Products Association, 2013; Council of Forest Industries, 2013).

Unfortunately, the forces of climate change threaten this delicate relationship. The latest climatic models project significant changes to the future distributions of forested ecosystems, showing that climate change is indeed changing the complexion of forests in Western Canada. For instance, Wang *et al.* (2012) predict that the climate in British Columbia in 2080 would be more conducive to grassland and dry forest habitats, but less favourable for boreal, alpine, and subalpine forest ecosystems. The long temporal scales associated with the business of growing trees means that these future shifts in forest productivity have major implications for forest managers today. Not only is the provision of vital ecosystem services compromised, but so too is the health and vitality of rural forest-dependent communities. Given that the vast majority of forestlands in Western Canada are publicly held, the general populace needs to be made aware of these changes, and given an opportunity to voice their concerns.

All that being the case, several reforestation strategies to adapt our forests to climate change and to maintain the current character of Western Canada's forests, have been put forward. These strategies range from simple seed selection and tree breeding to more interventionist measures like assisted migration and genetically engineered species[1]. While the planting of genetically modified trees is prohibited in operational

[1] Assisted migration is the deliberate movement of species to locations that could better suit them in future climates (Aubin *et al.* 2011). Genetically engineered species are organisms that have had their genomes directly manipulated using biotechnology, often introducing new genetic material to the organism.

forests on crown land (Government of British Columbia 2005), in all likelihood, solutions to this complex climate change mitigation problem will reside in the use of biotechnology in one form or another.

Broadly defined, biotechnology refers to "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use" (United Nations, 1992). Since 1970, there has been an ever-increasing body of social science research addressing public perceptions of biotechnology (Pin and Gutteling 2009). In Europe, this research is largely focused on food and agriculture (Skogstad, 2011), while in North America, the focus has been on the field's health applications (Pin and Gutteling 2009). While the social science literature addressing biotechnology in forestry is increasing, there remains a dearth of targeted studies. To date, very little work has been conducted on understanding public perception of biotechnology within the context of forest management and, what has been done, focuses predominantly on genetic modification to the exclusion of other practical applications of the technology.

Past research on the degree to which the public at large accepts biotechnology solutions in general has produced highly variable findings. While some studies have noted the public becoming increasingly concerned with the use of biotechnology strategies, there is evidence to suggest support in agricultural applications (Gaskell *et al.*, 2000; Priest, 2000). Other studies have pointed to a general lack of knowledge about what biotechnology actually entails (Hoban, 1997; Priest, 2000; Blaine *et al.*, 2002). Stelzer and Goldfarb (1997) and Walter (2004) echo the results above within the specific context of forestry.

There have been assertions that the public debate surrounding biotechnology in forestry will be less than that surrounding biotechnology in agricultural crops (Tuskan, 2004). These assumptions, however, may be unfounded (Hall, 2007). For example, a survey of environmentalists in Scotland found that participants' concerns regarding the risks associated with genetic modification in food crops were often linked to concern regarding environmental risks (Hall, 2007; Hall and Moran, 2006). Respondents were also surer of environmental risks than they were of health risks. Given the lengthy rotation associated with operational forestry, and the reproductive

ecology of trees in general (larger seed dispersal distances and lengthy reproductive lives - Williams, 2005) it is possible that these environmental concerns might be heightened (Gamborg and Sandøe, 2010).

That as a backdrop, the purpose of this current paper is to assess the general public's level of acceptance of various reforestation strategies — many of which revolve around biotechnology — that have the potential to be used in adapting forests to future climate conditions in Western Canada (Alberta and British Columbia), and to assess whether acceptance levels correlated with various demographic factors. In addition, we sought to explore whether certain potential outcomes of these strategies would cause people to accept strategies that they had previously rejected (or reject what they had previously accepted) to get a sense for what factors would cause people to change their minds about the strategies. Lastly, the opinions of community leaders of forest-dependent communities in the two provinces are evaluated in an attempt to see how well they align with those of the public-at-large.

METHODS

Two online survey instruments were developed for this study using FluidSurveys (fluidsurveys.com), and administered to two different samples: one to the general public in both British Columbia and Alberta, and the other to leaders of forest-dependent communities in both provinces. Each survey and the associated sampling strategies are described in turn.

For the public survey, the online panels of *ResearchNow*, a research and marketing survey company, were used. Their panels were roughly representative of populations in both provinces in terms of demographic characteristics like age and gender. Given the inherently rural nature of this particular research problem, quotas were programmed into the online survey. These quotas limited the number of respondents living in the major urban centres of Vancouver and Victoria to 54% of the BC sample and the number of respondents living in Calgary and Edmonton to 52% of the Alberta sample. These percentages are proportional to actual populations in those urban centres relative to the total population of each province and avoided an over-representation of major metropolitan areas within the panel samples.

The questionnaire itself elicited respondents' opinions on different forest management (reforestation) strategies that could be used to help forests adapt to climate change. After providing an explanation to respondents on the impacts that climate change could have on forests in Western Canada and on how current forest management strategies, tree growth, and survival may not be optimal given changing climate conditions, respondents were presented with six different management strategies related to replanting trees after forests have been logged. They were asked to rate their levels of acceptance for each strategy on a four-point scale (completely reject, tentatively reject, tentatively accept, and completely accept, with an additional "don't know" option). The strategies, recreated in Table 1, were meant to represent an array of options ranging from a 'do nothing' approach with no human or technological interference (Strategy 1) to a technologically-intensive intervention of genetic engineering of tree seedlings (Strategy 6). Between these two strategies was a gradient of strategies incorporating progressively more technological and human interference: Strategy 2 – active replanting with local seedlings; Strategy 3 – replanting with local seedlings that have been bred for optimal growth under changing climate conditions; Strategy 4 – replanting with non-local seedlings that have also been optimally bred (assisted migration within the species range); and, Strategy 5 – replanting with optimally-bred seedlings of species present in the province, but that had not previously been in that location (assisted migration that extends the species range).

Upon rating their acceptance of each strategy, respondents were asked whether or not they would change their answer if the strategy led to certain outcomes. Based on their initial responses, three scenarios relating to differing socio-economic conditions, forest aesthetics, and forest disturbances were presented to the survey participants. For example, if they had initially rejected a strategy, they were then asked whether or not they would accept it if it led to improved socio-economic conditions in forest-dependent communities or decreased incidences of pest and disease or fire. They were also asked whether they would change their answer if they learned that the strategy was the *status quo* — how forests are currently actually managed. The logic and exact wording of this set of questions is seen in Table 2.

Respondents were also given space to add open-ended comments on these management strategies and explain why they may have accepted some, but rejected others. Finally, the questionnaire also solicited basic demographic information, including place of residence, age, gender, and level of education.

For the community leaders survey, 48 forest-dependent communities in British Columbia and 16 in Alberta were identified. These were defined as having at least 10% of the community's employed labour force in the forest sector, indicating a significant role in the economy[2]. Through collaboration with the Union of BC Municipalities, invitations to complete the online survey were emailed to each community's Mayor and Council in British Columbia. For the Alberta communities, emails were sent directly to each community's Mayor and Council, as well as town managers / chief administrative officers, where possible.

Although their opinions are not a proxy for those of their community members, elected officials were targeted for this survey under the assumption that their perceptions — as elected representatives and policy makers — of public acceptability would be of interest on the topic of how climate change is impacting local forests. Thus, while similar questions were asked of them as of the general public, the questions to the community leaders were occasionally reworded to ensure that they distinguished between their own opinions and their perceptions of their constituents' opinions. For example, the same forest management strategies were presented to the community leaders as to the general public, but the leaders were asked to make choices that they thought would be acceptable to their constituents.

After an initial period of pretesting, the public survey was administered between 6 and 25 July 2012, which was how long it took until the desired sample size of 1,500 complete responses (750 from each province) was reached. The community leaders survey was open for one month, from 23 October to 23 November 2012 in British Columbia, and from 16 May to 17 June 2013 in Alberta.

[2] The 10% cutoff is used in the Canadian Forest Service (CFS) forest dependence guidelines. Forest dependence is shown as the proportion of the employed labor force that is employed in the forest sector over the total employed labor force (Stedman *et al.*, 2007).

In order to understand how acceptance of the forest management strategies varied according to certain demographic characteristics, the acceptance construct was transformed into a binary variable. The responses "completely accept" and "tentatively accept" were grouped together as an acceptance of the strategy in question. While recognizing that this aggregation of the data loses the nuance of a four-point scale, it allows for an efficient yet telling representation of the results. Pearson's chi-square tests (alpha = 0.05) were used to determine associations between acceptance and the various demographic variables.

RESULTS AND DISCUSSION

Response rates and nonresponse

The response rate for the public survey was 23%. The final usable sample size was 1,544 respondents, after eliminating incomplete responses (86% completion rate amongst those who responded) and 'racers' (those who took less than six-and-a-half minutes to complete the survey[3], presumably by not reading through the questions).

Given that this online survey was administered all at once (with a single invitation to participate), and completed relatively quickly, nonresponse bias could not be tested by comparing early and late responders, so we opted to compare demographic information with known population characteristics as described by Armstrong and Overton (1977). Specifically, we compared our sample data on age distributions, gender, and population distributions (provincial, urban versus rural) against known population statistics sourced from various databases (Alberta Office of Information and Statistics, 2014; BC Stats, 2014; Statistics Canada, 2014). For each demographic variable, we tested proportions of respondents against known population proportions using z-tests (alpha = 0.05).

With only one exception, no significant differences were observed, indicating that the response patterns in our survey generally follow the demographic patterns for BC and Alberta, and that the sample had valid coverage. The one exception revolved around age distributions. A significantly higher proportion of respondents between the ages of 20 to 39 was observed in our sample, as well as a concomitantly lower proportion

[3] Pre-testing of the survey indicated that six and a half minutes was the minimum amount of time required to read through all the questions and respond to them.

of respondents between the ages of 60 to 69. Given the requirement of a computer and some degree of computer literacy to complete an online questionnaire, this result is not unexpected; Palmquist and Stueve (1996) suggest that younger individuals are more apt to respond to online surveys than older segments of the population. While this result is notable, it is not necessarily indicative of nonresponse bias (Sax *et al.*, 2003), and the general demographic patterns observed in this study seem to indicate that, if nonresponse bias is present, it is negligible. That said, results of this survey should be approached with some caution, as certain opinions may be skewed towards a younger demographic.

Public opinions

53.7% of respondents resided in British Columbia and 45.5% resided in Alberta (0.8% in other provinces). 53.8% of respondents lived in Vancouver, Victoria, Edmonton, or Calgary (major metropolitan areas – MMAs), with 46.2% living outside these cities (non-MMAs), reflecting the 2011 population censuses (www.statcan.gc.ca). The sample was gender-balanced (49.2% male; 48.4% female; 2.3% no response). Age structure, when grouped in 20-year intervals, follows a normal distribution, with the average age being 49. 53.7% of the respondents had completed a university or college degree or higher.

Levels of acceptance of forest management strategies

Levels of acceptance of the six forest management (reforestation) strategies in Table 1 are seen in Figure 1. The results showed: low acceptance for a 'do nothing' strategy that allows climate change to run its course without any human intervention (Strategy 1); high acceptance for aiding the forest to regenerate by re-planting with local seeds (Strategy 2); a decreasing acceptance of strategies that involve increasingly more manipulation such as breeding (Strategy 3), breeding and moving seeds (Strategy 4), breeding and moving seeds outside the species' natural range (with a large decrease in acceptance for moving seeds around the province) (Strategy 5); and low acceptance of GMOs (Strategy 6). The proportion that answered "don't know" increased in small increments from Strategy 1 (0%) to Strategy 6 (8%).

Many respondents explained their choices in responses to the open-ended question in the survey. Some of the themes that consistently emerged are summarized here.

It seems that many of the respondents confused assisted migration that extends a species range with the introduction of exotic or invasive species; the survey did not mention exotic (not normally found in their province) or invasive species. Yet many respondents commented on this anyways:

> *Introducing completely new species to an area has been shown in the past to create imbalances and change the whole landscape.*
>
> *Introducing new species to different areas is dangerous.*
>
> *We have tons of invasive species and plants already that started out as someone planting a seed, so how can we be sure introducing new species won't cause problems?*
>
> *There are so many examples where new species have completely overrun the populations that were previously present, to the extent where it is detrimental to the ecosystem.*

These reactions reflect the complex debate, even among scientists, on what is considered an invasive and/or exotic species (Boonman-Berson *et al.,* 2014). However, it can be argued that assisted migration strategies differ from past human-mediated species introductions. Given the devastating impacts that introduced invasive species have had on natural ecosystems in the past, assisted migration in Western Canada is now done under high levels of scrutiny and regulations (Aubin et al. 2011). Furthermore, the assisted migration strategies described in the survey stated that seedlings would be sourced from species already existing elsewhere in the province; while it is difficult to predict which introduced species will become invasive, plants that are translocated shorter distances are much less likely to do so (reviewed in Aubin *et al*. 2011). Yet many participants equated the assisted migration strategy with past negative experiences with exotic or invasive species. Perhaps this was due to a misreading of Strategy 5, or that the strategy itself was unclear. However, that seedlings would be sourced from elsewhere in the province was clearly stated in the survey; jumping to the conclusion that these would be exotic or invasives is a

reflection of the respondents' own experiences or biases.

Both moving seedlings and planting GMOs produced strong reactions from respondents, with many drawing the line before accepting GMOs:

> *We do not want to mess with the balance of the forest or introduce species that are not currently part of the natural mix, nor do we wish to participate in GMO species.*

> *I strongly believe that we should continue to plant seedlings from the same species of trees that have grown here for thousands of years. The trees themselves will adapt to climate change.*

> *There is a large difference in my mind between non-local versus selectively choosing local seeds. If the trees didn't grow in an area before, then there would be a reason for it and we should respect that.*

> *Natural selection will ensure the forest species adapt to what is best for their survival. It may take a lot longer, and it may not produce the forest we "want", but it will produce the forest that should be.*

> *I accept any solution to save the environment except using genetically engineered seeds/plants.*

Yet respondents seemed to be slightly more accepting of planting genetically-engineered seeds, and much more accepting of moving seeds suited to projected climates, than of the natural regeneration strategy. Given that GMOs are often a 'hot button' topic, this could be interpreted as, 'doing something is preferable to doing nothing'. On the other hand, the high rejection ascribed to a 'do nothing' strategy could merely be a reflection of a generally negative reaction to the notion of not replanting at all after harvesting. Suffice it to say, these are complex and nuanced issues, which some respondents believe will require some sort of 'techno-fix':

The climate is changing and human intervention to help our forest adapt to these changes before our forests are decimated is a move that I strongly agree with.

I think it will become essential to look at GMO's for our survival in a rapidly changing environment.

Levels of acceptance of forest management strategies by demographics

Interestingly, the general trend of acceptance levels in Figure 1 is mimicked regardless of the respondents' location (MMA versus non-MMA), province, gender, age, education level, or occupation/sector, with only a few statistical differences observed by location, province and gender for certain strategies (Figures 2 through 4). A slightly higher proportion of respondents in non-MMAs accepted strategies involving more human intervention, but this difference was only statistically significant for Strategies 3 and 5. Respondents in Alberta were statistically more accepting of a 'do nothing' strategy than their counterparts in British Columbia. There were no statistical differences observed by gender, with the exception that a statistically larger proportion of men accepted Strategy 6 (GMO's) than women (Figure 4). While there have been no studies of this type eliciting public perceptions on assisted migration to compare these findings to, these results are somewhat inconsistent with the literature on public perceptions of GMOs that shows that higher levels of education and income are correlated with higher degrees of acceptance for genetic modification technologies (Heiman *et al.* 2000). However, Florkowski *et al.* (1994) and Moerbeek and Casimir (2005) also reported that males are more likely than females to perceive GMOs positively.

Changing minds

For each of the six forest management strategies that they were presented with, respondents were asked whether or not they would change their answer if the strategy led to particular outcomes related to socio-economics of forest-dependent communities, forest aesthetics, and pest, disease and/or fire outbreaks. Figure 5 shows the proportion of respondents who accepted the strategy if it led to favourable outcomes, after initially rejecting it, while Figure 6 shows the proportion who rejected the strategy after initially accepting it if it led to unfavourable outcomes.

Figure 5 shows that there was a high proportion of respondents who would change their answer after initially rejecting a ‘do nothing’ strategy. This might indicate that people reject the ‘do nothing’ strategy at first because they think it will not deal well with future conditions, but if they were told that it would, in fact, result in favourable outcomes, they would change their minds. This willingness to change their answers based on favourable outcomes seems to decrease with greater degrees of human intervention, the extreme case being that few respondents who initially rejected the use of GMOs were willing to accept their use even if it resulted in better outcomes. This indicates that negative opinions were more strongly-held when it came to more manipulative strategies, particularly the use of GMOs. In terms of the outcomes, a decrease in pests and diseases and forest fires seemed to have the highest degree of potency for changing minds regarding their willingness to accept a strategy, with improved socio-economic conditions following behind in second place.

Interestingly, Figure 6 shows that willingness to reject a strategy after having initially accepted is less dependent on the particular strategy involved or the degree of intervention; similar proportions of respondents changed their answer to rejection for all of the strategies. Instead, this willingness was highly linked to the particular outcome. Many were willing to change their minds if presented with information suggesting that the strategy is not as effective as they might have thought: most respondents (75-83% across the strategies) who initially accepted the strategy rejected it if it increased the incidence of pests, disease, and fire, regardless of the strategy used; and fewer, although still many (35-47%), rejected it if it led to worse socio-economic conditions.

Overall, across all strategies and potential outcomes, people changed their answers to accept a strategy 35% of the time after initially either rejecting it or not knowing, and 39% of the time after initially accepting the strategy. A high proportion of people changing their answers when presented with different outcomes reinforces the idea that, beyond just having reactions to degrees of manipulation of nature, people weigh the benefits and the costs of such strategies when given more information on these. If a strategy that respondents were initially opposed to was shown to lead to favourable outcomes, many were willing to change their minds and accept that strategy, and vice

versa for negative outcomes. Rather than holding onto original opinions, one could argue that people have complex evaluative schemes that respond to presented evidence (Fischhoff and Fischhoff 2001). Given this, it is likely that if the possible outcomes or the pros and cons of each strategy were presented initially, results would have differed.

However, it is important to reiterate that, even with more information presented on positive outcomes, many people still did not accept the more interventionist strategies, particularly GMO use. The argument could be made that GMO debates are more present in the public discourse, resulting in people being more likely to have built stronger opinions based on more information, and thus less likely to change their minds about GMO strategies, regardless of the additional information presented. It would, however, be difficult to argue this for the assisted migration strategies, which have yet to be discussed extensively in the public sphere. That said, it is interesting to note that those who initially accept the strategies are more often willing to change their response than those who initially reject them.

Leaders of forest-dependent communities

For the survey of community leaders in BC, 49 responses were received, 37 of which were complete. Of the 48 forest-dependent communities identified in British Columbia, 26 communities were represented in the sample. In all cases, either one or two representatives from a community provided complete responses, with the exception of one mid-sized community in British Columbia, where four respondents completed the survey. Only three complete surveys were received from Alberta, out of seven responses, representing three of 16 forest-dependent communities.

Respondents were mostly city councilors (38.8%), mayors (16.3%), or chief administrative officers (8.2%). 49% of respondents were male, 22.4% were female (28.6% did not respond to the gender question). 36.7% had completed a university or college degree or higher, and 42.9% had held their position in local governance for between one and five years.

The community leaders' acceptance levels of the different forest management strategies posited to deal with climate change impacts mirrored those of the public[4]: low acceptance of a 'do nothing' approach (Strategy 1); high acceptance of replanting with local seeds; and a decreasing acceptance of strategies that involve higher levels of human intervention (Figure 7). Again, the community leaders were slightly more accepting of using genetically-engineered seeds, and much more accepting of moving seeds, than the natural regeneration strategy.

Some community leaders used the opportunity of responding to the open-ended question to emphasize the importance of diversification — both economically and ecologically — above all else, as the way forward for their communities:

> *It is very important to diversify the forest types of trees so that when an epidemic such as the pine beetle occur there would be less damage to the overall forest and [it] would be easier to control. It would also assist in the lumber markets as different varieties would be available for future harvest.*

> *I would prefer planting native species in areas not currently known to be the preferred climate with as much diversification as possible.*

Others expressed reservations towards — or outright rejection of — the strategies that incorporate higher levels of human manipulation:

> *I feel that communities need to diversify. However, I am not sold on the idea of alternative forest management practices. I feel that GMO, extra-providence trees, as well as assisted migration are not acceptable ways to manage for future stands. Trees grown locally, and not genetically enhanced, still have the genetic variability to survive future climates.*

> *The idea of using seed from the local area makes sense in that we know it grows here, but any of the other scenarios should be done as trials so we can understand the full impact of species conversion as it relates to climate change.*

[4] Given the vast difference in sample sizes (n=1,544 and n=40 for the public sample and the community leader sample, respectively), statistical differences between these two groups were not assessed.

We do not want to mess with the balance of the forest or introduce species that are not currently part of the natural mix, nor do we wish to participate in GMO species.

There are huge concerns about GMO products in this area. Much education would be needed and there would still be significant pushback.

Conclusion

This research aimed to assess the level of acceptance of various climate change adaptation reforestation strategies, including the potential role of biotechnology, in Alberta and British Columbia. Specifically, the views of the general public in these two provinces were solicited, as well as the degree to which these views coincided with those of community leaders in the forest-dependent communities of Western Canada. Both sample groups — the general public and forest-dependent community leaders — were aligned regarding the levels of acceptability of the range of presented forest management strategies, with both groups being least comfortable with the prospect of forests left to re-grow naturally. Both groups were generally accepting of at least some level of human intervention in reforestation, with residents in major metropolitan areas being slightly less accepting than their rural counterparts. In the final analysis, residents and community leaders in Western Canada seemed most comfortable with reforestation strategies that involve using only locally collected seed stock.

Interestingly, there emerged what can broadly be characterized as some degree of malleability with respect to the opinions of Alberta and British Columbia residents regarding the acceptability of forest management strategies. In other words, perceptions do not entirely depend on the intervention strategy or the technology itself, but rather on its perceived potential consequences. Many respondents were willing to change their opinions if it led to particular forest-based outcomes related to socio-economic wellbeing, aesthetics, and the incidence of fire, pests, and disease. In terms of reforestation strategies and the use of biotechnology, it appears that, in some cases, the ends can indeed justify the means. However, there are also thresholds pertaining to the use of biotechnology in forest management. The finding that a large number of

participants were unwilling to change their negative or neutral opinion regarding the introduction of genetically modified trees (GMOs) is reflective of a general public concern found in previous studies relating to genomics in agricultural crops (e.g., Hall and Moran, 2006).

The analysis of open-ended comments in the surveys reveals that some residents in Western Canada — not surprisingly, given that most do not have forestry backgrounds — may have been somewhat confused with the seemingly nuanced distinctions between the forest management strategies presented in this study. This, coupled with the fact that respondents showed a willingness to change their minds when presented with additional outcome-oriented information, forms the basis for a key takeaway message for forest policy-makers. The likely starting point to allow for a dialogue on forest reforestation strategies to adapt to future climate conditions to emerge would be to discuss and clarify terms, technologies, and potential outcomes with residents of Alberta and British Columbia, particularly in rural, forest-dependent communities. For interested stakeholders to meaningfully participate in this dialogue, they will require a more robust understanding of the current forest management practices, proposed reforestation strategies, and technological interventions. However, importantly, this discourse cannot be isolated to the acceptability of various forest management actions in terms of ecological risks and benefits; it must incorporate a discussion of which values and services (social, economic, aesthetic, forest health, etc.) Western Canada's forests are to be managed for. Creating a space for meaningful public dialogue where concerns can be expressed and misperceptions can be more deeply understood is exceptionally useful during this time of rapid environmental change. If the government demonstrates a willingness to work with the public on addressing concerns, more trusting relationships can be formed as these new policies are operationalized (Beierle, 1999). The public is a powerful force, and through transparent and meaningful engagement, the likelihood of achieving consensus-based solutions is increased.

We wholly acknowledge the limitations of this study and, more generally, public surveys in effectively gathering opinions on biotechnology. For example, there was the potential for bias to be introduced in the way that the six forest management strategies were presented to respondents, not randomly, but in an order that mimicked

increases in human and technological interventions. It would have been interesting to see if similar results would have been obtained if the strategies were presented in a random order; in essence, not aiding the respondent to think of each strategy as being more highly manipulated than the last. Additionally, while our sample roughly followed demographic patterns in British Columbia and Alberta, the presence of non-response bias skewed towards younger respondents could not be completely eliminated. Furthermore, while they were always presented with an option to choose "I don't know" as a response, it is difficult to know whether respondents fully understood the nuances of all the strategies when accepting or rejecting them. This reinforces that, while information collected in this study can be helpful in informing next steps for policy-makers regarding forest adaptation, this cannot be a substitute for public debate and proper information dissemination (Davison *et al.*, 1997). Rather, this study should be thought of as a preliminary assessment of public attitudes in Alberta and British Columbia. Moving forward, the public-at-large, particularly those most likely to be affected by these decisions, should be engaged in a transparent and meaningful information-sharing and deliberation process around managing our forests for tomorrow's climate.

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Table 1. Six different forest management strategies for which respondents rated their levels of acceptance.

Strategy 1: Forests are left to re-grow naturally, with no intervention by forest managers. This means climate change is allowed to run its course without any management to help forests adapt.
Strategy 2: Forest managers plant seedlings grown from seeds that are collected from forests close to the planting area.
Strategy 3: Forest managers plant seedlings grown from seeds that are collected from forests close to the planting area, but breeding takes place to select local seeds that are expected to grow well in the climate conditions expected to occur in the near future.
Strategy 4: Forest managers plant seedlings grown from seeds that come from non-local forests (i.e. forests that are distant from the planting area). Breeding takes place to select seeds that are expected to grow well in the climate conditions expected to occur in the near future.
Strategy 5: Forest managers plant seedlings from seeds of tree species that are different species than what had been there previously. As in the last strategy, the seeds are collected from another region within the province, and breeding takes place to select seeds that are expected to grow well in the climate conditions expected to occur in the near future.
Strategy 6: Forest managers plant seedlings grown from seeds that are genetically engineered (genetically modified organisms, GMOs) to grow well in the climate conditions expected to occur in the near future.

Table 2. Scenarios for determining whether respondents would change their levels of acceptance for six different forest management strategies.

For each strategy, if respondent's answer was:		
Completely or tentatively reject…	**Completely or tentatively accept…**	**Don't know**
Would you accept this strategy if it led to more favourable socio-economic conditions in forest-dependent communities?	Would you reject this strategy if it led to less favourable socio-economic conditions in forest-dependent communities?	Would you accept this strategy if it led to more favourable socio-economic conditions in forest-dependent communities?
Would you accept this strategy if it led to forests looking different than they do today (i.e. different species, different densities, different survival rates, etc)?	Would you reject this strategy if it led to forests looking different than they do today (i.e. different species, different densities, different survival rates, etc)?	Would you accept this strategy if it led to forests looking different than they do today (i.e. different species, different densities, different survival rates, etc)?
Would you accept this strategy if it led to a decrease in occurrence of forest fires and/or pest outbreaks?	Would you reject this strategy if it led to an increase in occurrence of forest fires and/or pest outbreaks?	Would you accept this strategy if it led to a decrease in occurrence of forest fires and/or pest outbreaks?
Would you accept this strategy if you learned that this is how forests were currently being managed?	Would you reject this strategy if you learned that this is how forests were currently being managed?	Would you accept this strategy if you learned that this is how forests were currently being managed?

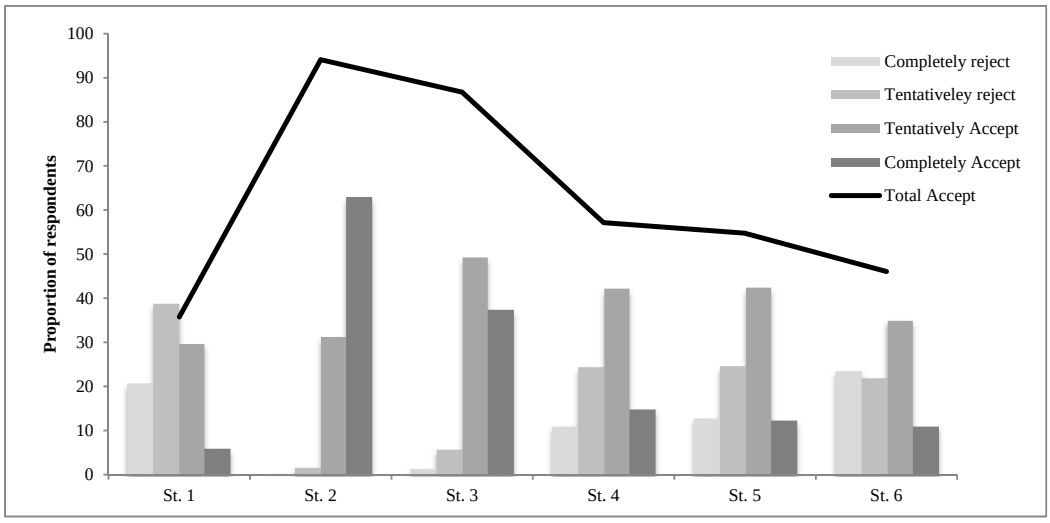

Figure 1. Public's acceptance of six forest management strategies (see Table 1 for description of strategies).

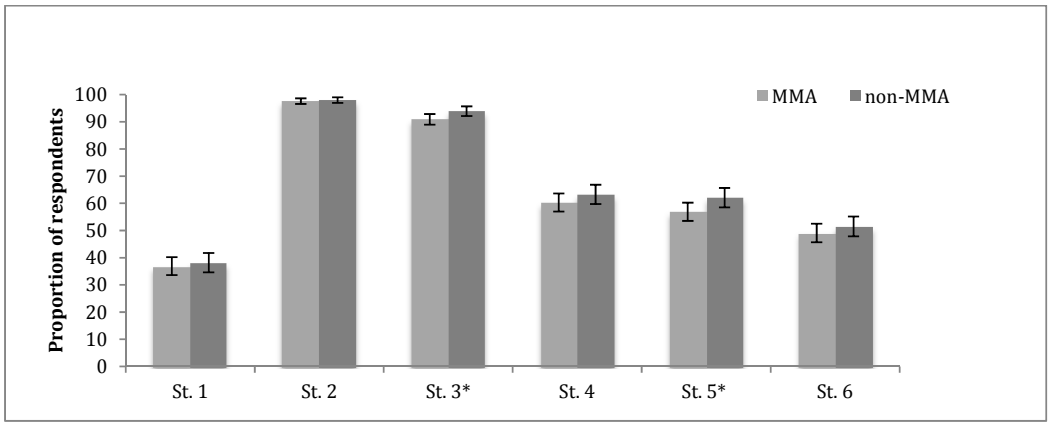

Figure 2. Total acceptance of strategies by respondent's location (MMA versus non-MMA). * indicates that column proportions differ significantly from each other at p=0.05.

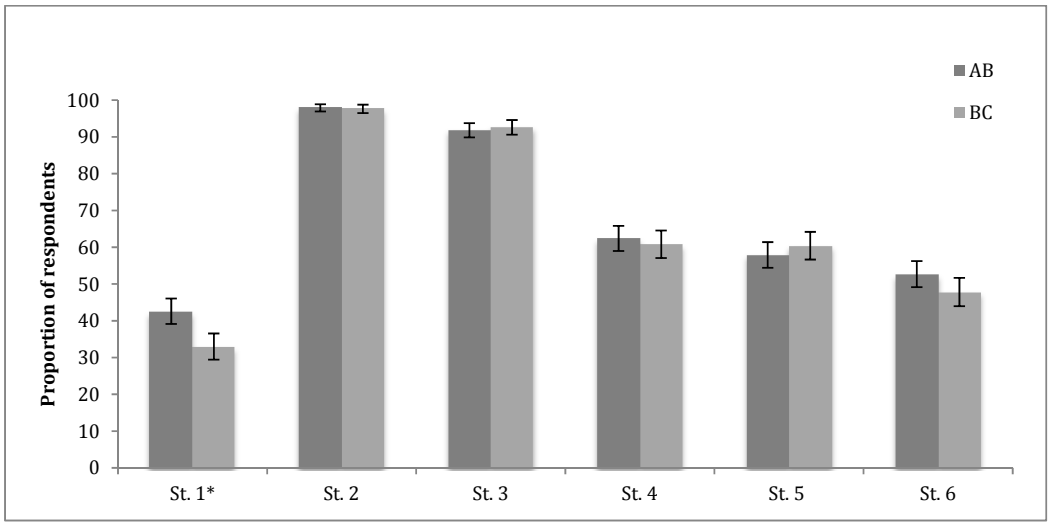

Figure 3. Total acceptance of strategies by respondent's location (Alberta versus British Columbia). * indicates that column proportions differ significantly from each other at p=0.05.

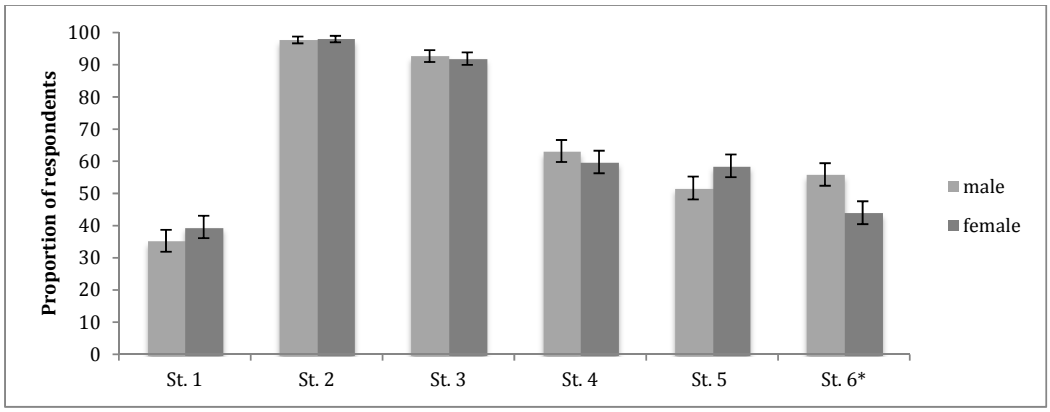

Figure 4. Total acceptance of strategies by gender of respondent. * indicates that column proportions differ significantly from each other at p=0.05.

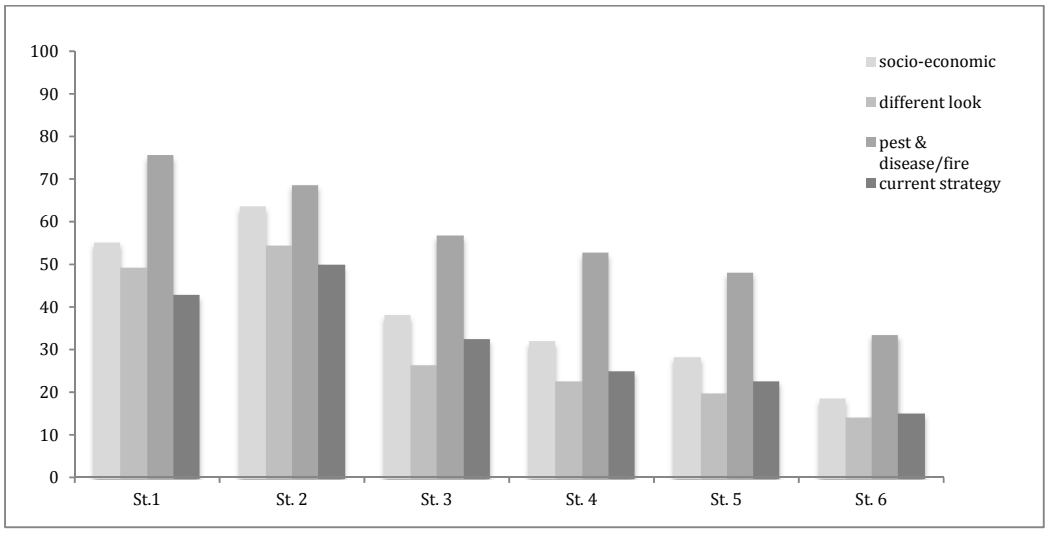

Figure 5. Proportion of public survey respondents who when presented with possible outcomes of a management strategy, accepted a strategy they had initially rejected. For an explanation of the outcomes listed in the legend, see methods. For an explanation of Strategies see Table 1.

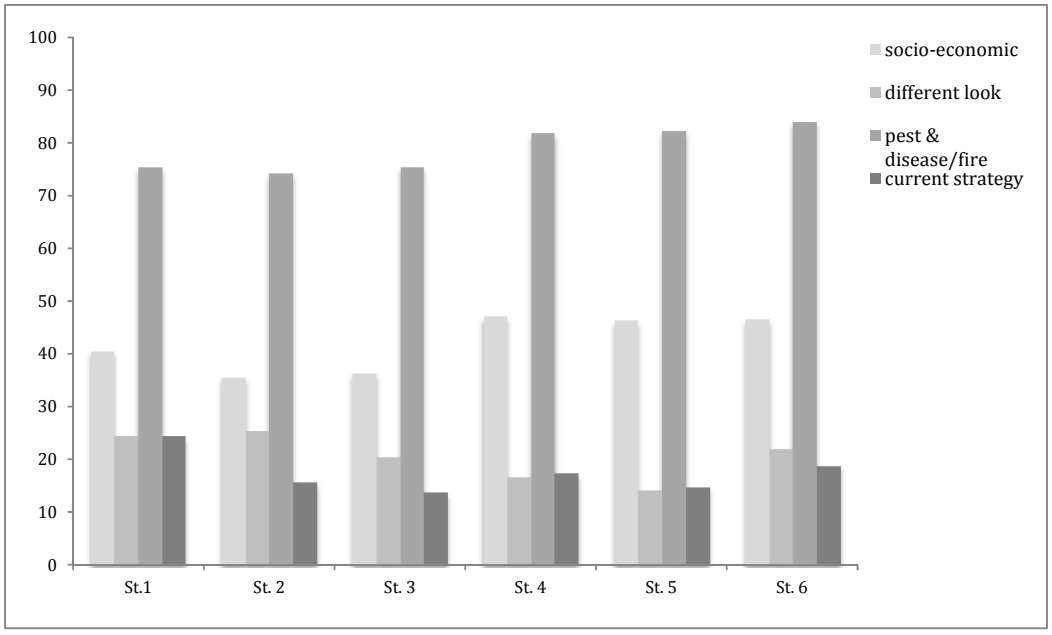

Figure 6. Proportion of public survey respondents who rejected a management strategy they had initially accepted, after being presented with negative possible outcomes. For an explanation of the outcomes listed in the legend, see methods. For an explanation of Strategies see Table 1.

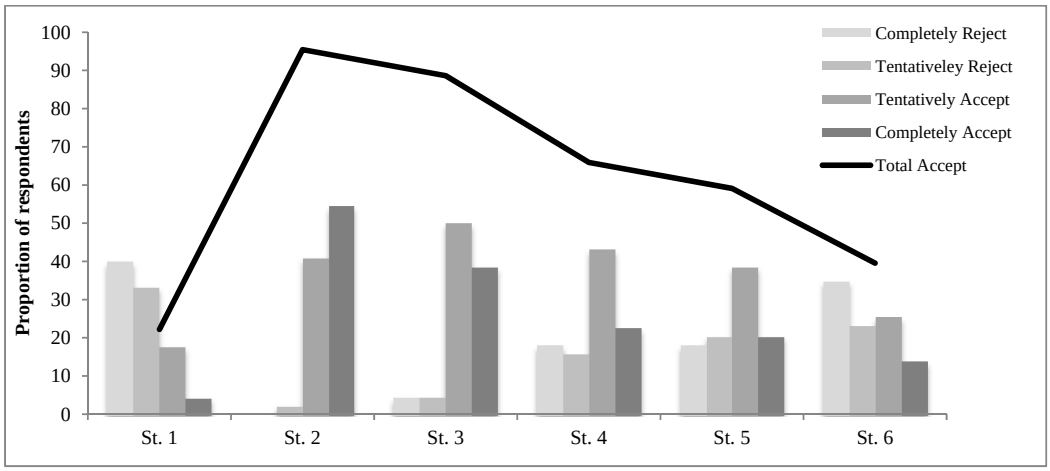

Figure 7: Community leaders' acceptance of various forest adaptation management strategies.