Exploring Preferences for Poplar Biotechnology and Integrated Choice Latent Variable Models

by

Curtis Rollins,

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Agricultural and Resource Economics

Department of Resource Economics and Environmental Sociology
University of Alberta

Abstract

This thesis is divided in two papers, each focusing on a distinct issue. In the first paper (Chapter 2), public preferences for poplar biotechnology are examined in western Canada. Using a sample of the public from British Columbia, Alberta, Saskatchewan, and Manitoba, respondents were asked to vote in a series of hypothetical referenda comparing proposed forest policies to the current policy. Proposed policies varied based on poplar breeding method (traditional, genomics, or genetic modification) and whether poplars may be used as a biofuel feedstock. British Columbians were least accepting of new policies promoting poplar biotechnology or genomics on public land, while Albertans were most accepting. Little variation in policy acceptance was noted between different breeding methods, though genetic modification is least preferred. Policies involving poplar-derived biofuel production were preferred to policies involving no biofuel production. Respondents who were more certain of their voting choice were less likely to prefer a proposed policy versus the current policy. The second paper (Chapter 3), examines an integrated choice latent variable (ICLV) model in comparison to other choice models. The ICLV model allows for simultaneous estimation of models of individuals' latent attitudes and choices. While attitudes are often specified as observed covariates in the social sciences to gain explanatory power, this approach may result in biased estimates, which the ICLV model addresses. Using the Albertan data subset, the ICLV model is compared to a model specifying attitudes as observed variables (No ME model). No significant differences in effects on the choice outcome were detected between the No ME and ICLV models. However, the No ME model is prone to Type I and II errors when estimating the effects of demographic variables on the choice outcome. Thus, the largest benefit of the ICLV model seems to be its ability to estimate relationships between latent and observed variables.

Preface

This thesis is an original work by Curtis Rollins. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name "Public Perceptions of Planting Exotic Trees on Public Land", No. Pro00040179, July 15, 2013.

Acknowledgements

There are many people in the Department of Resource Economics and Environmental Sociology that have made this journey possible enjoyable. First off, I must thank Peter. It wasn't until the final year of my undergraduate program that I took one of his courses, which was a turning point in how I viewed my education. Suddenly, I was able to figure out the importance and linkages behind all the seemingly random concepts that were thrown at me over the past few years, and how to apply this broad base of knowledge effectively. I'd like to thank Marty for his hard work and support throughout this project. It made a huge difference to have such a passionate and engaged co-supervisor helping out along the way, especially given how many projects and students he was juggling at the time. I'd like to thank Sandeep for providing me with many great insights into my statistical methods for this project, but especially for being a great Econometrics teacher. I never did well or felt engaged in a statistics course until I was faced with his significantly more difficult, graduate-level course. I think Sandeep deserves at least half of the credit for this. I'd also like to thank all the staff and other students for providing such a fun and laid-back atmosphere (Uncle Pete's Club and the Office of Productivity, especially). Last, I have to thank Robin. She never hesitated to go above-and-beyond when I needed help with anything, and I'm certain that my graduate school experience would have been much more difficult without her all her efforts and positivity.

I would also like to acknowledge Genome Canada, Genome Alberta, and Alberta Innovates: Bio-Solutions for funding this project, and I am grateful for the Al Brennan Memorial Scholarship for helping fund my studies.

Last, and most importantly, I must thank my family and friends for providing many welcomed distractions from my thesis, and Anna for being so supportive all along the way.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1: Background

Genomics and breeding research has been applied to forestry for a variety of desired outcomes, including increased timber quality and growth rates, pest resistance, and climate-change adaptation (Genome Canada 2014). As a greater understanding of tree genetics has been developed, more novel and fine-tuned research questions are being examined. For instance, the POPCAN project is investigating genetic improvements of poplars as bioethanol feedstock (Genome British Columbia 2014). It is possible that POPCAN or other genomics research will realize widespread application in the future of Canadian forestry, and that poplars could become a major contributor to Canadian bioethanol production. However, 93% of Canadian forested land is publicly owned and is subject to regulations regarding parent tree sources for reforestation (Natural Resources Canada 2012). Thus, most genomics-based tree-breeding research programs are incompatible with public land regulations, and are therefore not compatible with the Canadian forest industry since they depend on wider breeding pools than are allowable on public lands.

As genomics research may have transformative impacts on society, Genome Canada uses a framework examining such research on ethical, environmental, economic, legal, and social (GE^3LS) grounds (Genome Canada 2015). This component of genomics research is essential in identifying and understanding challenges and opportunities related to applications of genomics, and therefore the feasibility of these applications coming to fruition. If POPCAN research were to be applied on Canadian public land, numerous potential outcomes could be realized. On one hand, POPCAN could result in a more prosperous forest industry, a reduction of agricultural inputs directed to bioethanol rather than food production, and could aid Canada in reducing greenhouse gas emissions. On the other hand, replacing large portions of public land with non-native trees could result in genetic flow from improved poplars to native poplars, resulting in uncertain environmental consequences (Guigou-Cairas 2008). Due to these potential benefits and risks associated with POPCAN, and because large-scale applications of forest genomics research may rely upon plantations on public land, public opinion of this research and its predicted outcomes is one of many crucial GE^3LS topics.

Minimal research has been conducted on public opinions of genomics in forestry. Two studies, by Hajjar et al. (2014) and Harshaw (2012), reported minimal public support for allowing genetically improved trees on public land. However, Hajjar et al. note that public support increases substantially if planting genetically improved trees results in positive economic, social, or environmental outcomes, yet also decreases substantially if negative outcomes were to be realized. Thus, it seems that public opinion of applying genomics research in Canadian forestry is highly dependent on the associated outcomes of doing so.

When analyzing factors affecting public opinions of genomics and breeding research in forestry, links between characteristics of individuals and their opinion of different tree-breeding methods are unclear (Hajjar et al. 2014). These unclear results are echoed in other fields studying public opinion of biotechnology and genomics, such as food and health applications (Costa-Font et al. 2008; Pin & Gutteling 2009). To add clarity to this issue, some researchers have relied on latent characteristics of individuals, such as attitudes, to explain public opinion of biotechnology (e.g. Costa-Font & Gil 2012). While the concept of using latent characteristics as covariates in models of opinion or preference is not new, authors often rely on simplified methods to do so, which may result in biased estimates in models using qualitative dependent variables (Train et al. 1987). To address this issue in a discrete choice-modeling context, researchers have developed the integrated choice latent variable (ICLV) model, combining statistical methods from a wide range of social science disciplines to jointly and accurately model respondent attitudes and preferences (Walker 2001).

This thesis seeks to address two main research topics, and is separated into two distinct papers (chapters 2 and 3), with a fourth chapter dedicated to conclusions of the research. First, public opinion of various poplar-breeding methods will be evaluated in British Columbia, Alberta, Saskatchewan, and Manitoba. This first research area is addressed in chapter 2. Specifically, chapter 2 will examine the following research questions:

1) How does public opinion of genomics in forestry compare to other breeding methods;
2) Which members of the public are more likely to support forest policies and practices allowing for genomics and non-native trees on public land;
3) To what degree does the public support using public land to grow poplars as a bioethanol feedstock; and,

4) Which potential outcomes and policy changes associated with allowing non-native poplars to be planted on public land does the public deem most important?

Second, an ICLV model examining public opinion of genetically improved poplars in Alberta will be estimated, in order to evaluate the potential benefits of this modeling approach. This research area is addressed in chapter 3. The ICLV model will be compared to a basic choice model relying only on observed covariates, as well as a choice model that incorrectly specifies latent variables as observed covariates, thereby introducing parameter bias. Specifically, chapter 3 will address the following research questions:

1) Does the ICLV model provide an improvement over a basic choice model in terms of model fit statistics and explanatory richness;
2) Do estimates between an ICLV model and a choice model specifying latent variables as observed variables significantly differ; and
3) In Alberta, which attitudes are correlated with public acceptance of forest policies are practices allowing for non-native trees on public land?

To summarize the findings of these two papers, conclusions will be discussed in chapter 4.

1.2: Literature Cited

Costa-Font, M., & Gil, J. M. (2012). Meta-attitudes and the local formation of consumer judgments towards genetically modified food. *British Food Journal*, *114*, 1463-1485.

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy*, *33*, 99-111.

Genome British Columbia. (2014). *Research Projects: POPCAN*. Retrieved October 28, 2014 from http://www.genomebc.ca/research-programs/projects/energy-mining-environment/popcan.

Genome Canada. (2014). *Research Portfolio: Forestry.* Retrieved December 12, 2014 from http://www.genomecanada.ca/en/portfolio/project/forestry.aspx.

Genome Canada. (2015). *GE^{3}LS: Genomics & Society.* Retrieved March 26, 2015 from http://www.genomecanada.ca/en/ge3ls/.

Guigou Cairus, G. (2008). *Estimating Genetic Flow Between Exotic and Native Poplar Species in Quebec.* (Master's Thesis, University of Laval).

Hajjar, R., McGuigan, E., Moshofsky, M., & Kozak, R. (2014). Opinions on strategies for forest adaptation to future climate conditions in Western Canada: Surveys of the general public and leaders of forest-dependent communities. *Canadian Journal of Forest Research*, *44,* 1525-1533.

Natural Resources Canada. (2012). The State of Canada's Forests: Annual Report 2012. Cat. No. Fo1-6/2012E-PDF.

Pin, R. R., & Gutteling, J. M. (2009). The development of public perception research in the genomics field: An empirical analysis of the literature in the field. *Science Communication*, *31,* 57-83.

Train, K. E., McFadden, D. L., & Goett, A. A. (1987). Consumer attitudes and voluntary rate schedules for public utilities. *Review of Economics and Statistics 69*, 383-391.

Walker, J. L. (2001). *Extended discrete choice models: integrated framework, flexible error structures, and latent variables* (Doctoral dissertation, Massachusetts Institute of Technology).

Chapter 2: Public Opinions of Planting Genetically Improved Poplars on Public Land for Biofuel Production in Western Canada.

2.1: Introduction

Genomic and tree-breeding research has been conducted in hopes of achieving a variety of desired outcomes, including pest-resistance, climate-change adaptation, or increasing wood quality and volume (Genome Canada 2014). One specific project, POPCAN, aims to harness genomic information to improve the suitability of poplars[1] as a cellulosic biofuel feedstock via multiple generations of breeding (Genome British Columbia 2014). In 2010, the Government of Canada mandated that gasoline for transportation vehicles comes from renewable sources at a minimum of 5% on average (Minister of Justice 2013) in an effort to mitigate greenhouse gas emissions. Canada may need to look beyond agricultural biofuel sources to aid in meeting the minimum renewable fuel requirements into the future, and forest resources could become a contributor. However, 93% of Canadian forested land is publicly owned, which is subject to regulations regarding the types of trees that may be planted (Natural Resources Canada 2012).

Due to public land regulations, many tree-breeding research projects are often unable to realize widespread application under current policy conditions Specifically, most provinces require that trees planted on public land come from seed collected within a certain range of the planting site. For example, 90 seed zones are defined in Alberta (Alberta Environment and Sustainable Resource Development 2009). Some breeding programs may not be feasible under this system, as each zone is subject to a small breeding pool, and would require unique research.. As the application of POPCAN research, as well as other forest genomic research, would likely need to occur on public land and require public land policy change to become a reality, public evaluation of the technology is one of many key considerations moving forward.

This paper seeks to measure public acceptance of planting various types of hybrid or genetically improved poplars on public land in the four western Canadian provinces. To assess public acceptance, a number of hypothetical policies surrounding tree breeding and biofuel production were proposed, and potential effects of each policy were estimated. Survey respondents were then asked to vote between their province's current forest policy and the

---

[1] In this paper, the term "poplar" represents trees of the *Populus* genus, which includes poplar, aspen, and cottonwood.

proposed policies in a series of hypothetical referenda. Proposed policy options were driven by three breeding methods (traditional selective breeding, genomic-assisted breeding, and genetic modification, or GM) with improved poplars planted on public land, each with and without resulting poplar-derived biofuels. This methodological approach permits understanding of levels of acceptance between different policy options. Further, understanding will be gained with respect to which members of the public are more willing to support such policies, and why these policies may or may not be perceived as acceptable.

2.2: Literature Review

While there are numerous studies of public perceptions of biotechnology applications to food and health (Costa-Font et al. 2009; Pin & Guttelling 2009), few have specifically examined applications to forestry. This gap in the literature is partly explained by the relative novelty of the use of genomics in forestry in comparison to other fields, but could also be due to forests sharing a less direct relationship with the public than food or medicines. However, the public seems to perceive similarly low levels of risk of GM trees and GM food when compared to other environmental risks[2] (Slimak & Dietz 2006; McFarlane 2005), so results from food biotechnology preference studies may be similar to forestry applications.

Two studies have examined public perceptions of applications of genomics in Canadian forestry. Harshaw (2012) examined the BC public's acceptance of poplar plantations to be used as biofuel feedstock. 44% of the BC public agreed with large-scale poplar plantations being used to provide biofuel feedstock on private land (29% disagreed, and 26% were uncertain), while only 15% agreed with replacing natural forested public land with plantations aimed at biofuel production (66% disagreed, and 19% were uncertain) (Harshaw 2012). Hajjar et al. (2014) gauged public acceptance of using a variety of breeding methods and strategies to adapt public forests to climate change in BC and Alberta. The authors found that a strong majority of the public accepted replanting local seedlings or selectively breeding with local seed (similar to tree

---

[2] When comparing 24 different risks to the environment, Slimak & Dietz (2006) found that GMOs were ranked 23rd by both risk assessors and the public (clear-cut logging ranked 11th and 12th by risk assessors and the public, respectively). McFarlane (2005) compared risk perceptions of different threats to forest biodiversity in BC, and GM trees were ranked 12th of 15 potential risks by the public, with only hunting, grazing, and recreation being perceived as lesser risks (logging practices were again perceived as a greater risk than GMOs).

improvement programs), while higher levels of breeding technology (genomics and GM) and breeding with non-local seeds were accepted by approximately 50% of respondents. The Alberta and BC publics were found to be least accepting of allowing the forest to grow back without replanting efforts. Hajjar et al. did not include outcomes associated with different tree breeding strategies when assessing public acceptance, but asked respondents if their preference would change in the case of future benefits or costs with respect to economics, aesthetics, and forest disease or pests were associated with each tree-breeding and reforestation strategy. Many respondents implied that their vote would change in light of resulting costs or benefits, implying that public opinions of forest biotechnology applications are partially dictated by the predicted outcomes of different reforestation strategies (Hajjar et al. 2014).

The relationship between acceptance of biotechnology and characteristics of individuals is ambiguous in both forestry and food applications (Hajjar et al. 2014; Costa-Font et al. 2008). Hajjar et al. (2014) found that forest biotechnology acceptance was weakly explained by demographic variables. Males were more likely to accept GM trees; Albertans were more likely to accept not planting seedlings post-harvest than British Columbians; and respondents living outside of major cities were more likely to accept policies involving more human intervention. In an assessment of risks to forest biodiversity, McFarlane (2005) found that more educated respondents perceived higher levels of risk related to forestry activity and land conversion, and females and older respondents perceived higher levels of risk associated with land conversion. In food biotechnology acceptance studies, numerous authors have found strong relationships between acceptance and factors such as sex, age, or education, while many others have found no significant links (see review by Costa-Font et al. 2008). These results may be explained by the high variability of GM food acceptance studies, in terms of region and products.

Studies of public preferences for forest-based biorefineries in the United States also found inconsistent relationships with characteristics of individuals. In a three-state sample (Arkansas, Florida, and Virginia), few results were consistent between samples (Susaeta et al. 2010). A higher education level was a significant positive predictor of forest-based biofuels in one sample, while older respondents were less likely to accept biofuels in one sample. The authors also found that a reduction in carbon emissions arising from biofuels increased acceptance in two samples. In another American study, Marciano et al. (2014) found that more educated individuals were less likely to accept forest-based biofuels. Both studies also examined how potential outcomes associated with forest-based biofuels affect acceptability. Environmental benefits (sustainability or reduction in carbon emissions) were positively linked with biofuel acceptance in both studies, while Marciano et al. (2014) found increased economic development is positively linked to acceptance. Marciano et al. (2014) also found multiple outcomes of forest-based biofuel production negatively associated with biofuel acceptance, such as traffic, water pollution, and odor issues in areas near biorefineries.

2.3: Methods

2.3.1: Questionnaire Design

Questionnaire design involved numerous stages of consultation with scientific experts (geneticists, botanists, and forest scientists) and the general public. First, four focus groups were held to assess the public's understanding of the questionnaire topic and to present an early draft of hypothetical referendum questions, which outlined attributes and impacts of various policy options relative to the current policy. Participants for all public focus groups were recruited by random-digit-dialing by Advanis Inc., an Edmonton-based market research firm. Two focus groups each were held in Edmonton, Alberta (16 participants) and Grande Prairie, Alberta (17 participants). Next, a survey was sent to a group of forestry experts to gather data on predicted changes in poplar growth rate and value arising from different breeding methods and allowing breeding stock to be chosen from anywhere in the world. Draft scenarios for hypothetical referenda were developed based on the expert estimates of increases in growth and value of poplars using different breeding methods. A discussion was then held with a group of experts involved with POPCAN (Genome British Columbia 2014) to ensure the information provided in the questionnaire was accurate. Following further reviews, a final round of public focus groups were held, with two groups held in Edmonton, Alberta (24 participants) and North Battleford, Saskatchewan (22 participants). This round of focus groups aimed to ensure that all elements of the questionnaire were understood, and to reduce potential sources of bias. After completing these phases and resulting edits to the questionnaire, a pre-test version was administered online to 102 members (51 Albertans and 51 British Columbians) of an internet panel maintained by Ipsos Canada, a market research firm. The final questionnaire briefly explained information about biofuels, different tree breeding methods, and the relevant province's current forest composition, industry, and policy. Next, a series of hypothetical referendum questions were presented with follow-up questions, and demographic information was collected last.

In total, six proposed policy scenarios were created for the referendum tasks. The six proposed policy scenarios were driven by two key attributes: the tree breeding method employed, and whether or not poplars would be used for biofuel production. Three breeding methods examined are traditional selective breeding (*Trad*), genomics-assisted breeding (*genome*), and genetic modification *(GM*). Each breeding method appeared in one proposed policy scenario including biofuel production (referred to as *Trad + BF, genome + BF, and GM + BF*) and another with no resulting biofuel production (referred to as *Trad no BF, genome no BF,* and *GM no BF*). Each voting scenario was set up as a provincial referendum, where respondents were asked to vote for either the new proposed policy, or to stay with the current policy.

An example referendum question is presented in Figure 2.3.1. In addition to the breeding method and biofuel production policy attributes, supplemental information was presented for each referendum question. The additional information selected was based on focus group discussions during the survey development phase. First, improved poplar breeding details are presented in terms of parent tree source and breeding method. All proposed policies (right-most column) involve worldwide seed selection for improved poplars, while the current policy involves a small amount of selectively bred poplars (on less than 0.1% of land) using local breeding stock to represent a small amount of breeding trials in each province. Next, estimates of commercial public forest land-use are provided, comprised of non-harvested forest (forest land falling within a FMA with no future harvest plans), and land with harvested coniferous trees, natural poplars, and improved poplars. In the referendum exercise, harvested coniferous treed land is constant for the current and all proposed policies. Harvested natural poplar land refers to harvested land regenerated naturally via roots and seeds of harvested poplars. Impacts of proposed policies on industry were included with three possible categories depending on the gains associated with different breeding methods: small, moderate, and strong positive impacts. Carbon emission reductions arising from replacing gasoline with poplar-derived biofuels were represented by the estimated equivalent in cars driven per year.

Policy and Management Features	Current Policy and Management Approaches	New Policy and Management Approaches
“Improved” Poplars On Commercial Public Forest Land in Alberta		
Region where parent trees are located	Parent trees come from the same region as regenerated trees	Parent trees can come from any location
Breeding method	Traditional breeding using observed traits	Breeding assisted by genetic information (DNA markers)
How <u>commercial public forest</u> land in Alberta is used	 Non-Harvested (40%) Harvested Coniferous Trees (40%) Harvested Natural Poplars (20%) Harvested “Improved” Poplars (less than 0.1%)	 Non-Harvested (48%) Harvested Coniferous Trees (40%) Harvested Natural Poplars (9%) Harvested “Improved” Poplars (3%)
Impact on forest industry in Alberta (jobs and income)	No change	Moderate positive impact
Reduction in carbon emissions in Alberta from using poplar biofuels	None	Equivalent to 120,000 cars off the road per year in Alberta

Above each table, respondents were asked, “Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?”

Figure 2.3.1 – Example of a hypothetical referendum question (*Genome + BF* scenario) used to measure public preferences for using different Poplar breeding technologies for use on public land.

Current commercial forest land-use was calculated for each province using a variety of sources, depending on data availability. British Columbia forest land-use was calculated using a collection of 40 timber supply area analysis reports prepared by the British Columbia Ministry of Forest, Lands, and Natural Resource Operations (2014), and Alberta forest land-use was calculated based on data from Alberta Environment and Sustainable Resource Development (2013). For Saskatchewan and Manitoba, data was not easily available from the provincial governments, so land-use was estimated based on information released by forestry firms[3]. Predicted changes in land-use arising from allowing different breeding methods and worldwide seed selection on public land were determined using simulation results from Anderson et al. (2012). All policies assumed an equal annual-allowable-cut (AAC), implying the same volume of timber is harvested in each scenario. Technically, higher tree growth rates could imply a higher annual-allowable-cut (AAC) instead of leaving some areas unharvested, but a constant AAC was assumed to avoid confounding the area planted to genetically improved poplars with different tree breeding methods.

The impact of allowing new tree breeding methods on the forest industry (jobs and income) was estimated using a combination of results from Anderson et al. (2012), the expert tree growth and value survey, and forest industry composition in each province (proportion of hardwood to softwood production from Natural Resources Canada (2009) and current land-use). Estimates of reduction in carbon emissions per year was based on 5% of Alberta's gasoline being replaced by Poplar-derived biofuel, using a low (65-70%) estimate of life-cycle analysis carbon emission reduction of second-generation biofuels from Schmer et al. (2008), and gasoline consumption data from Statistics Canada (2013). As there is little previous research on public approval of different tree breeding methods, we aimed to keep voting exercise simple and limit the number of new policies. Thus, while it could be informative to allow land-use, impact on industry, and changes in carbon emissions to freely vary in the choice experiment, these attributes are strictly correlated with the breeding method and biofuel production attributes for the sake of simplicity.

Attribute levels for each policy are listed in Table 2.3.1. Each proposed policy is defined by its breeding method and whether poplar-derived biofuel production occurs. In the choice experiment, each respondent evaluates all six proposed policies versus the current policy.

---

3 Reports from Mistik Management Ltd. (2013) and Saskaw Askiy Management Inc. (2013) for Saskatchewan, and reports from LP Canada Ltd. (2014) and Tolko Industries Ltd. (2014) for Manitoba

Table 2.3.1 – Policy attributes associated with different proposed forest policy and management approaches for each province.

		Policy Attribute Levels			
		Commercial Forest Land-Use (%)		Impact on Industry	Carbon Emission Reduction (Cars per year)
Prov.	Policy	Non-Harvested	Improved Poplar		
AB	Current	40%	<0.1%		
	Trad no BF	46%	3%	Small	
	Trad + BF	46%	3%	Small	120,000
	Genome no BF	48%	3%	Moderate	
	Genome + BF	48%	3%	Moderate	120,000
	GM no BF	49%	3%	Strong	
	GM + BF	49%	3%	Strong	120,000
BC	Current	40%	<0.1%		
	Trad no BF	42%	1%	Little to no	
	Trad + BF	42%	1%	Little to no	90,000
	Genome no BF	43%	1%	Small	
	Genome + BF	43%	1%	Small	90,000
	GM no BF	43%	1%	Moderate	
	GM + BF	43%	1%	Moderate	90,000
MB	Current	60%	<0.1%		
	Trad no BF	63%	2%	Small	
	Trad + BF	63%	1%	Small	30,000
	Genome no BF	64%	1%	Moderate	
	Genome + BF	64%	1%	Moderate	30,000
	GM no BF	65%	1%	Strong	
	GM + BF	65%	1%	Strong	30,000
SK	Current	40%	<0.1%		
	Trad no BF	46%	3%	Small	
	Trad + BF	46%	1%	Small	50,000
	Genome no BF	48%	1%	Moderate	
	Genome + BF	48%	1%	Moderate	50,000
	GM no BF	49%	1%	Strong	
	GM + BF	49%	1%	Strong	50,000

A hypothetical referendum approach was chosen as it has been found to be an accurate predictor of a real referendum (Vossler et al. 2003), and is incentive compatible (Carson & Grooves 2007). However, there are potential issues with the hypothetical referendum approach that must be addressed. Hypothetical means of measuring choices may lead to biased responses. To investigate robustness of voting results, additional questions were included. After each referendum question, respondents were asked to rate how certain they were of their vote on a four-point Likert scale (*very uncertain, somewhat uncertain, somewhat certain,* and *very certain*). Past studies have found that those who are *very certain* provide realistic results, while other responses are less reliable (Blumenschein et al. 1998; Ready et al. 2010). Another issue arises from the specific public approval elicitation method used in this study. Since only two policy attributes of the five listed in the hypothetical referenda freely vary (breeding method and biofuel production), it is not possible to understand the importance of the attributes that do not freely vary. To address this, respondents were asked to indicate how important each policy attribute was when deciding on their vote choice on a five-point Likert scale (with options *not at all important, not important, neutral, important,* and *very important*).

2.3.2: Questionnaire Administration

The questionnaire was administered online to members of an internet panel maintained by Ipsos Canada, a market research firm. The goal was to obtain a representative sample of the Alberta, British Columbia, Manitoba, and Saskatchewan populations. Using an online format allowed for color graphics in the information and hypothetical referendum sections, randomized orders of hypothetical referendum questions, and providing a hyperlink to information and definitions when answering choice questions. The internet panel maintained by Ipsos Canada consists of over 200,000 members actively maintained to be representative of the Canadian population based on demographic information. Participants were recruited with quotas on age, gender, and municipality population to increase each province's sample representativeness of its population demographics. To decrease sampling bias within the panel, respondents were provided with an incentive from Ipsos Canada, and were not informed of the study topic when invited to participate. Internet surveys may face issues of sampling bias, as internet access is a requirement. However, an increasing proportion of Canadians are accessing the internet at home over time. In 2012, 83% of Canadians had internet access, an increase from 79% in 2010 (Statistics Canada 2013).

2.3.3: Econometric Methods

Economic theory posits that individuals seek to maximize utility, and will therefore choose the policy that makes them best off. Equation 1 represents the binary choice model for respondent *n* evaluating choice *m*. With a binary dependent variable, where the observed choice C_{nm} = 1 implies a vote in favor of a proposed policy, and C_{nm} = 0 implies a vote for the current policy, U_{nm} then denotes the latent utility associated with voting in favor of a proposed policy over the current policy.

$$U_{nm} = \alpha + \beta' X_n + \gamma' A_m + \nu_{nm} + u_n, \quad (1)$$

where $C_{nm} = 1$ if $U_{nm} > 0$, and $C_{nm} = 0$ otherwise.

In equation 1, X_n is a vector of respondent-specific characteristics, A_m is a vector of alternative-specific variables, α, β, and γ are estimated coefficients, ν_{nm} is a mean-zero normally distributed error term, and u_n is a respondent-specific error term. C_{nm} is the observed vote choice of respondent *n* evaluating vote *m*, and is expected to equal one if U_{nm} is positive, and zero otherwise. That is, it is predicted that a respondent will vote in favor of a new policy if the act grants them positive utility, and will vote in favor of the current policy if a vote for the new policy grants negative utility.

Equation 1 is estimated using a binary probit model. Since there are six responses per respondent, it is expected that error terms of the responses for each person will be correlated. To address this issue, a robust cluster-corrected Huber-White sandwich estimator is employed (Huber 1967; White 1980), which allows for ν_{nm} to be correlated for each cluster *n*, but assumes each cluster of error terms are uncorrelated with one another.

2.4: Results and Discussion

Sample and population demographics are outlined in Table 2.4.1. Females were slightly over-sampled relative to males in all provinces. In AB and BC, large cities (population greater than 100,000) were under-sampled, while small and medium cities were somewhat over-sampled. Samples and populations are very similar for MB and SK with respect to population centres. In general, all samples have higher post-secondary education rates than their respective populations. However, it is likely that population education rates are slightly higher than listed, as the population data refers to all Canadian residents over 15 years of age. In total, one response was dropped from the sample for completing the questionnaire unreasonably quickly (under 10 minutes), as most respondents took between 15 and 30 minutes for completion.

Table 2.4.1 – Comparison of socio-demographic characteristics between the 2014 sample used for this study (N) and 2011 Canada census data (pop.) for Alberta, British Columbia, Manitoba, and Saskatchewan.

	Province							
	AB		BC		MB		SK	
Characteristic	N	Pop.	N	Pop.	N	Pop.	N	Pop.
Number of Respondents	1205	-	1248	-	502	-	500	-
Male (%)	42	51	44	49	42	49	40	50
Average Age (18+)	48	45	49	48	50	47	50	47
Population of Centre of Residence (%)								
> 100,000	57	68	51	68	58	60	49	46
10,000 – 100,000	22	13	31	19	13	8	16	20
< 10,000	21	18	18	12	29	32	35	34
Post-Secondary Education Attained (%)	67	55	61	56	60	47	59	47

Education data from Statistics Canada (2012b); all other data from Statistics Canada (2012a).

Percentages of respondents voting in favor of a new policy over the current policy are displayed in Figure 2.4.1. Policies that assure that 5% of a province's gasoline sales would be replaced by poplar-derived biofuels (*i.e. Trad + BF, Genome + BF, and GM + BF*) are favored by a majority of respondents in each province. When comparing the provinces, Albertans voted in favor of a new policy over the current policy most often, while British Columbians voted in favor of a new policy least often. There is little variation in voting behaviour between different breeding methods within each province, implying that the public may be indifferent toward this policy attribute. However, when comparing policy situations that involve biofuel production, *GM* is less preferred than other breeding methods. This could imply that some who support biofuel production do not support GM technology use in forestry.

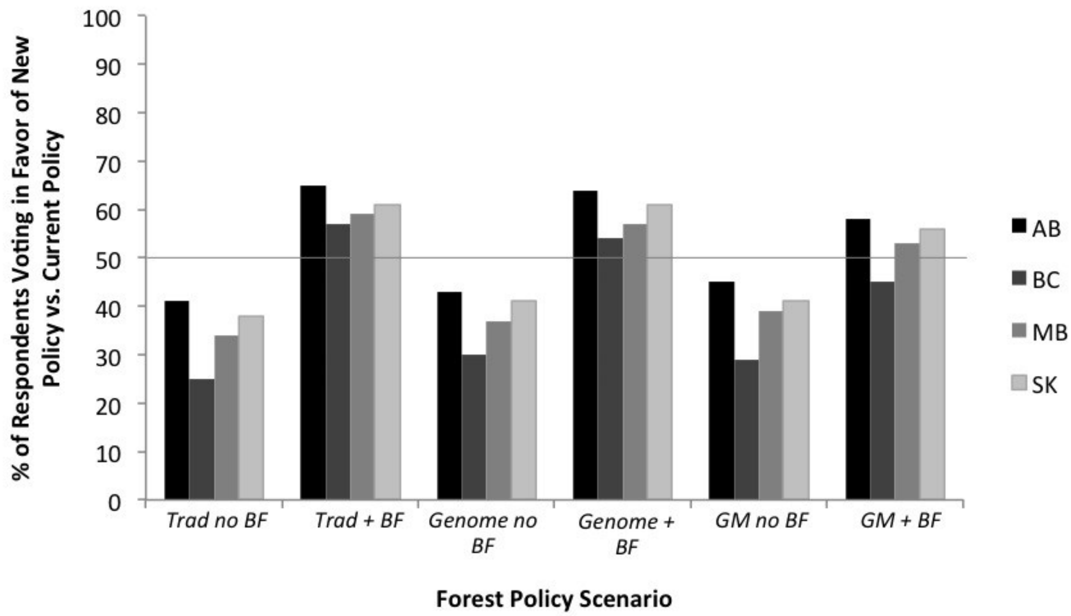


Figure 2.4.1 – Percentages of all respondents voting in favor of forest policies involving different breeding methods *(Trad, Genome,* and *GM)* and biofuel (*BF*) production over the current provincial policy situation in Alberta, British Columbia, Manitoba, and Saskatchewan.

Voting behaviour of respondents who were very certain of their choice is outlined in Figure 2.4.2. Depending on the province and voting scenario, approximately 20-25% of respondents were very certain of their vote choice. The generally low level of certainty provides evidence that the public may not be engaged in understanding forest biotechnology and breeding. Voting trends of very certain respondents are quite similar to the pooled results in Figure 2.4.1, but are approximately 10% lower in most cases. The largest disparity between all and very certain respondents exists in the BC sample for all policy scenarios. Very certain respondents from all provinces are less accepting of new policies resulting in no poplar-derived biofuels relative to votes of all respondents. For the *Trad + BF* policy, the reduction in public approval for very certain responses is minimal for AB, MB, and SK, but the disparity grows for breeding methods involving a higher degree of human control (*Genome no BF* and *GM no BF*).

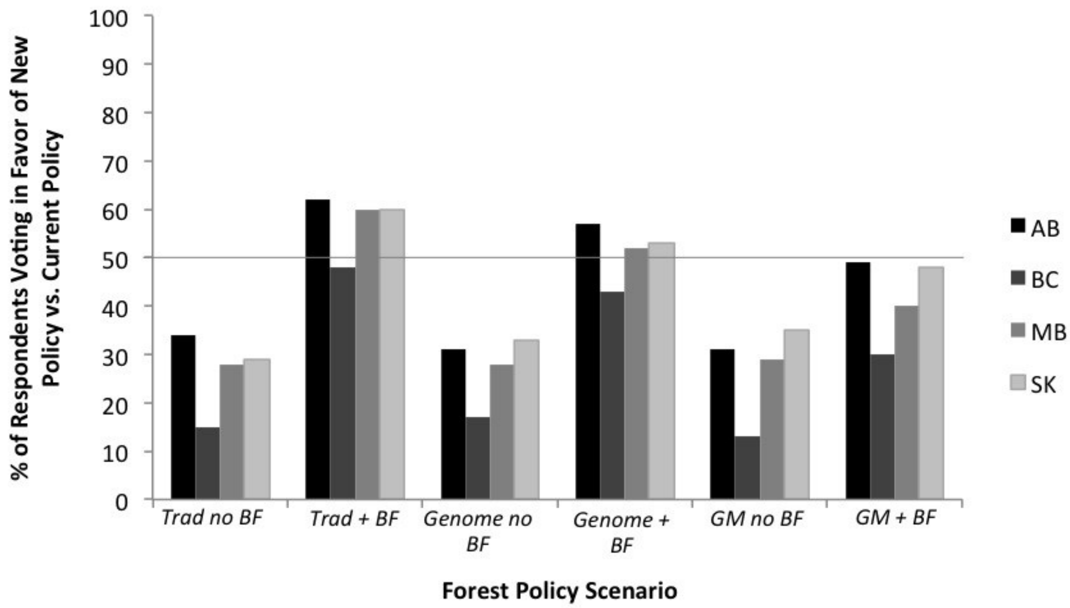


Figure 2.4.2 - Percentages of respondents who indicated they were *very certain* of their response voting in favor of forest policies involving different breeding methods (*Trad, Genome,* and *GM*) and biofuel (*BF*) production over the current provincial policy situation in Alberta, British Columbia, Manitoba, and Saskatchewan.

Taking the results from Figures 2.4.1 and 2.4.2 into account, there does not seem to be overwhelming public support for any new forest policy over the current policy. While *Trad + BF* and *Genome + BF* have the highest support from all responses, support levels become somewhat deflated when only taking very certain responses into account.

Results from estimating two probit models, one using all responses and one only using *very certain* responses, are presented in Table 2.4.2. In both models, the observed dependent variable equals 1 if the respondent voted in favor of the new proposed policy, and 0 if the current policy was chosen. The estimation procedure provided statistical tests to differentiate between vote totals presented in Figures 2.4.1 and 2.4.2, and also provide insight on how respondent-specific variables affect voting likelihoods. The third column for each model lists the marginal effect (ME). For continuous variables, the ME represents the change in likelihood of voting in favor of a new policy over the current for a one-unit change in the variable. Binary provincial and policy variables are effect-coded to ease with interpretation, so the ME reflects the change in likelihood of voting in favor of a new policy for a province or policy relative to the average likelihood of voting in favor of a new policy. Explained variance (pseudo-R^2) doubles when excluding responses that are not very certain, though only 24% of responses and 45% of respondents are represented in the second model. The amount of responses per respondent is unbalanced because certainty was measured for each vote. The percent correct predictions also improved by 7 points in the *very certain* model, up to 68% from 61%.

Table 2.4.2 – Coefficient, standard error (SE) and marginal effect (ME) estimates from binary probit models explaining the importance of factors affecting hypothetical forest policy referenda votes.

	All Responses			*Very Certain* Responses		
Variable	Coef.	SE	ME	Coef.	SE	ME
Male	0.071**	0.032	0.028**	0.288**	0.070	0.107**
Age	-0.005**	0.001	-0.002**	-0.009**	0.002	-0.003**
Post-Sec. Educated	-0.036	0.033	-0.014	-0.037	0.074	-0.014
AB[a]	0.126**	0.052	0.051**	0.108	0.113	0.040
BC[a]	-0.209	0.052	-0.083**	-0.383	0.112	-0.138**
SK[a]	0.085	0.062	0.034	0.097	0.136	0.036
Population[b]*:*						
<10,000	-0.096**	0.040	-0.038**	-0.214**	0.089	-0.077**
10,000-100,000	0.084	0.041	0.034**	0.038	0.089	-0.014
Policy Scenarios[c]*:*						
Trad + BF	0.708**	0.025	0.274**	0.832	0.051	0.321**
Genome no BF	0.099**	0.021	0.040**	-0.003	0.047	-0.001
Genome + BF	0.652**	0.025	0.253**	0.699**	0.052	0.270**
GM no BF	0.110**	0.023	0.044**	-0.040	0.050	-0.015
GM + BF	0.488**	0.026	0.192**	0.430**	0.053	0.165**
Constant	0.155**	0.078	-	-0.172	0.170	-
McFadden's R^2		0.049			0.098	
Votes		20730			4927	
(Respondents)		(3455)			(1561)	
Log-Pseudo-Likelihood		-13626.725			-2906.0523	
% Correct Predictions		61			68	

[*] Denotes significance at or above the 90% confidence level.
[**] Denotes significance at or above the 95% confidence level.
[a] Base (excluded) case is MB.
[b] Base (excluded) case is population > 100,000.
[c] Base (excluded) case is *Trad no BF.*

In the *all responses* model, policy scenario variables play a large role in predicting the probability of voting in favor of a new policy over the current policy, while demographic characteristics play a smaller role. Relative to the base policy scenario (*Trad no* BF), all other new policies were more preferable at or above the 95% confidence level. Adding biofuel production to the traditional breeding policy increases the likelihood of a respondent voting in favor of a new policy over the status-quo by 27%. This increased likelihood of public support decreases as more human control is involved in tree breeding, where a respondent is 25% more likely to vote for *genome + BF* and 19% more likely to vote for policy *GM + BF* in comparison to *Trad + BF*. A respondent is 4% more likely to vote for either *genome no BF* or *GM no BF* compared to the *Trad no BF* policy. Males are 2.8% more likely to vote for any new forest policy over the current policy, while an additional year of age is associated with a -0.2% change in likelihood of voting for a new policy. British Columbians are 8% less likely to vote for a new policy than Manitobans, while Albertans are 5% more likely. Last, respondents living in centres with populations under 10,000 and between 10,000-100,000 are 4% less likely and 3% more likely, respectively, to vote for a new policy relative to those living in centres with populations greater than 100,000.

For the model including only *very certain* responses, there is no significant difference between policies involving no poplar-derived biofuels. However, the likelihood of accepting a new policy with poplar-derived biofuels relative to policy scenario *trad no BF* is slightly higher than in the first model for policies *1b* and *2b* (32% and 27%, respectively). The *GM + BF* policy is 16.5% more likely to be chosen in comparison to *trad no BF*, which is a smaller magnitude than in the *all responses* model. Of the significant respondent-specific variables in the *very certain* model, all coefficients are of a greater magnitude than in the *all responses* model. Males are 11% more likely to vote for a new policy over the status-quo relative to females. An additional year of age is associated with a 0.3% decrease in the likelihood of voting for a new policy. British Columbians are 14% less likely to vote for a new policy over the current policy relative to Manitobans, and respondents living in population centres under 10,000 are 8% less likely to vote for a new policy in comparison to those living in large urban centres.

Socio-demographics generally exhibit low-magnitude or insignificant relationships with acceptance of forest policies that include biotechnology applications. This is not surprising, based on studies in forestry (Hajjar et al. 2014) and GM food (Costa-Font et al. 2008). The finding that males are more likely to support forest biotechnology than females is supported in some research (Hajjar et al, 2014; Costa-Font et al. 2008), though this relationship is of low magnitude in the *all responses* model and weak to moderate in the *very certain* model, and is perhaps explained by lesser perceptions of potential risk (McFarlane 2005). The affect of age on the likelihood of accepting a new forest policy over the status-quo is supported by McFarlane (2005), though this affect is also of a low magnitude. Assuming a constant marginal affect of age on the likelihood of voting for a new policy, there is only a 6% difference between a 20 year old and 50 year old in the *all responses* model, and a 9% difference in the *very certain* model. The finding that respondents living in small centres (under 10,000) or rural areas contradicts the findings of Hajjar et al. (2014), though this may be explained by differences in segmentations of the data by population. Education is insignificant in influencing forest policy acceptance, which is supported by Hajjar et al. (2014), but not MacFarlane (2005) and numerous GM food studies (Costa-Font et al. 2008), though these differences may be explained by differences in context.

It is difficult to dissect the underlying causes of provincial differences in voting behaviour. While on one hand, forest composition and the relevance of the forest industry to the provincial economy is quite different across the provinces, these differences resulted in distinct estimated policy impacts and current situations in each province. It is possible that British Columbians are less likely to accept exotic trees on public land because of a more engaged, environmentally-conscious public and prominent forest industry; but it is also possible that the difference is driven by the relatively low significance of poplars to industry and forest tree species composition, and therefore low benefits of allowing improved or exotic poplars on public land.

The public supports using poplars as a biofuel feedstock. For traditional and genomic-assisted breeding methods, policy acceptance is predicted to increase by 25-32% over a policy that just allows traditional breeding with worldwide seed selection, while this increase is lower for the *GM + BF* policy. This result suggests that while there are many supporters of biofuel, a proportion of biofuel supporters are against planting GM trees on public land. Hajjar et al. (2014) found similar results, as respondents are more likely to support a new policy if it is linked to additional environmental or economic benefits.

Neither choice model exhibits excellent explanatory power. This is at least partly driven by the lack of variation in many of the policy aspects communicated to respondents via referenda vote tables (see Figure 2.3.1). Respondents seem quite interested in genetic diversity and seed source (Hajjar et al. 2014), so varying these factors, among the other factors provided in the referenda vote tables, would likely provide more clarity on public acceptance of genomic technology in forestry. This idea is supported when voting trends for each respondent are analyzed, as 50% of the sample followed one of three distinct voting trends: 25% voted against all six new policies, 17% voted in favor of all six new policies, and 8% only voted in favor of all three policies involving poplar-derived biofuel production. Of the 25% who voted against every new policy, it is difficult to understand what drove their responses. To examine this issue further, respondents were asked to rate the importance of the policy attributes provided in making their voting decisions.

Table 2.4.3 lists mean ratings of importance of each forest policy attribute according to respondents on a 5-point scale (1 = *not at all important*, 5 = *very important*). To better understand the importance of each attribute that did not freely vary on its own relative to breeding method, the percentage of respondents who rated each other attribute as more, less, or equally important are also listed. Respondents rated seed source as the most important factor, with 24% rating it as more important than breeding method, and 55% rating it as equally important. After breeding method, change in carbon emissions resulting from poplar-derived biofuel production is the next most important policy attribute. Since carbon emissions reductions arising from poplar biofuel production was accounted for and has a major impact on policy acceptance, it follows that varying the seed source policy attribute should have a major impact on policy acceptance. Land-use change may also be varied independently of other policy attributes in future studies, and could significantly affect public acceptance of forest biotechnology policy aimed at genomics. It is likely that impact on industry must be a function of other policy variables and should be correlated with other policy attributes to some degree, though some variation in this factor is possible in future studies. Genetic diversity was not included in this study, but should hold importance in future research based on results from Hajjar et al. (2014).

Table 2.4.3 – Importance of each policy attribute when making vote decision as rated by respondents (1-5 scale), and importance of each attribute relative to tree breeding method (% of respondents indicating attribute is more, less, or equally as important as breeding method).

Policy Attribute	Mean Importance	Importance of Policy Attribute Relative to Breeding Method (% of Respondents)		
		More Important	Equal Importance	Less Important
Breeding Method	3.92	-	-	-
Seed Source (location)	3.95	24	55	21
Carbon Emissions (biofuels)	3.9	32	49	29
Land-Use Change	3.82	25	45	30
Impact on Industry	3.63	21	42	37

2.5: Conclusion

This study examined public opinion of using poplars developed via genomics-assisted breeding to be used as biofuel feedstock in BC, AB, SK, and MB. There was a focus on planting improved Poplars on public land due to high opportunity costs of using private agricultural land for plantations. Six new policy scenarios were estimated for each province and presented to respondents: using three different breeding methods (traditional selective breeding, genomics-assisted breeding, and GM), each with and without resulting Poplar-derived biofuels replacing 5% of the province's gasoline requirements. All proposed policy scenarios allowed worldwide seed selection for poplars in each province on public land to appropriately expand the breeding pool to maximize the gains of breeding Poplars while maintaining a constant AAC. Respondents were asked to vote in a series of hypothetical referenda between each potential new policy and the current policy, based on changes to forest land-use, breeding method, impact on industry, and impact on carbon emissions.

Strong provincial differences in public approval of new policies were found. These differences could be due to differences in knowledge and interest each province's citizens have in forestry; but could also be explained by provincial variation in forest industries and composition which respondents were informed of by the questionnaire. Across all new policies, British Columbians are least likely to accept a new policy over the current policy, and Albertans are most likely to support a new policy. Overall, no new policy was strongly supported by the public, especially when using measures of voter certainty to account for hypothetical bias. Further, the most highly accepted policies involved poplar-derived biofuels, and acceptance is contingent on 70% less carbon emissions from biofuels.

Aside from British Columbians, the public expressed minimal differences in approval of different breeding methods, whereas BC residents are more opposed to GM than other options. The majority of variation in voting behaviour was explained by the assurance of poplar-derived biofuels, which received strong positive reactions. Some socio-demographics were significant determinants of new policy acceptance, but most relationships were of low magnitudes.

The findings of this study are limited by a few factors. First, the policies presented to respondents could have been more realistic. It may be difficult to guarantee the production of poplar-derived biofuels in exchange for eliminating the requirement for local seeds, and a constant AAC may not be realistic when faster growing trees can be planted. Second, all policy changes were isolated to poplars, while softwood policy remained constant. It may be useful and more realistic to examine policies allowing broadening seed zones and allowing different breeding methods across each province's entire commercial forest land in future studies. Last, the hypothetical nature of the referenda may be prone to bias. While this issue was addressed by examining respondents who were very certain of their answers, this method excluded approximately 75% of responses, implying a large portion of the public may hold ambiguous preferences for forest biotechnology policy.

A level of ambiguity still remains in understanding public approval of genomic-assisted tree breeding in Canada. This ambiguity may be explained by an underlying lack of understanding of what a forest policy allowing genomic-assisted breeding on public land might look like, due to the variety of other policy attributes and forestry practices that must change to allow genomic breeding programs. This study and results from Hajjar et al. (2014) indicate that the public is highly responsive to positive and negative policy outcomes, so gaining a better understanding of how applications of genomics in forestry may impact society should allow for more clarity in establishing public preferences.

2.6: References

Alberta Environment and Sustainable Resource Development. (2009). Alberta Forest Genetic Resource Management and Conservation Standards. Report No. 978-0-7785-8467-4.

Alberta Environment and Sustainable Resource Development (2013). Forest management agreements: FMA holders. Retrieved November 2, 2013 from http://esrd.alberta.ca/lands-forests/forest-management/forest-management-agreements/fma-holders.aspx.

Anderson, J. A., Armstrong, G. W., Luckert, M. K., & Adamowicz, W. L. (2012). Optimal zoning of forested land considering the contribution of exotic plantations. *Mathematical and Computational Forestry & Natural-Resource Sciences*, *4*, 92-104.

Blumenschein, K., Johannesson, M., Blomquist, G. C., Liljas, B., O'Connor, R. M. (1998). Experimental results on expressed certainty and hypothetical bias in contingent valuation *Southern Economic Journal 65,*169–77.

British Columbia Ministry of Forest, Lands, and Natural Resource Operations (2014). Timber supply review: TSR and TSA schedule. Retrieved January 10, 2014 from http://www.for.gov.bc.ca/hts/aactsa.htm.

Carson, R. T., & Groves, T. (2007). Incentive and informational properties of preference questions. *Environmental & Resource Economics*, *37*, 181-210.

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy*, *33*, 99-111.

Genome British Columbia. (2014). *Research Projects: POPCAN*. Retrieved October 28, 2014 from http://www.genomebc.ca/research-programs/projects/energy-mining-environment/popcan.

Genome Canada. (2014). *Research Portfolio: Forestry.* Retrieved December 12, 2014 from http://www.genomecanada.ca/en/portfolio/project/forestry.aspx.

Hajjar, R., McGuigan, E., Moshofsky, M., & Kozak, R. (2014). Opinions on strategies for forest adaptation to future climate conditions in Western Canada: Surveys of the general public and leaders of forest-dependent communities. *Canadian Journal of Forest Research*, *44,* 1525-1533.

Harshaw, H.W. (2012). *Optimized Populous feedstocks and novel enzyme systems for a British Columbia bioenergy sector: Understanding the social context of strategies to develop biofuels from optimized Populus feedstocks – The British Columbia Bioenergy Survey*. Vancouver, BC: Department of Forest Resources Management, Faculty of Forestry, the University of British Columbia.

Huber, P. J. (1967). The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the fifth Berkeley symposium on mathematical statistics and probability* (Vol. 1, No. 1, 221-233).

LP Canada Ltd. (2014). Swan Valley forest management plan: documents. Retrieved January 15, 2014 from http://www.swanvalleyforest.ca/documents.html.

Marciano, J. A., Lilieholm, R. J., Teisl, M. F., Leahy, J. E., & Neupane, B. (2014). Factors affecting public support for forest-based biorefineries: A comparison of mill towns and the general public in Maine, USA. *Energy Policy*, *75*, 301-311.

McFarlane, B. L. (2005). Public perceptions of risk to forest biodiversity. *Risk Analysis, 25,* 543-553.

Minister of Justice. (2013). Renewable fuels regulations. SOR/2010-189. Accessed October 28, 2014 from http://laws-lois.justice.gc.ca/PDF/SOR-2010-189.pdf.

Mistik Management Inc. (2013). Mistik forest management agreement area. Retrieved November 3, 2014 from http://www.mistik.ca/fma.htm.

Natural Resources Canada. (2009). The state of Canada's forests: annual report 2009. Cat. No. Fo1-6/2009e.

Ready, R. C., Champ, P. A., & Lawton, J. L. (2010). Using respondent uncertainty to mitigate hypothetical bias in a stated choice experiment. *Land Economics 86,* 363-381.

Saskaw Askiy Management Inc. (2013). Management area: Prince Albert FMA. Retrieved November 3, 2014 from http://sakaw.ca/management_area.html.

Schmer, M. R., Vogel, K. P., Mitchell, R. P., & Perrin, R. K. (2008). Net energy of cellulosic ethanol from switchgrass. *Proceedings of the National Academy of Sciences, 105*, 464-469.

Slimak, M. W., & Dietz, T. (2006). Personal values, beliefs, and ecological risk perception. *Risk Analysis*, *26*, 1689-1705.

Statistics Canada (2012a). Population and dwelling counts, for Canada, provinces and territories, census metropolitan areas and census agglomerations, 2011 and 2006 censuses (table). Population and Dwelling Count Highlight Tables. 2011 Census. Statistics Canada Catalogue no. 98-310-XWE2011002.

Statistics Canada (2012b). 2011 National Household Survey. Statistics Canada Catalogue no.

99-012-X2011040.

Statistics Canada. (2013). Statistics Canada. Table 358-0167 - Canadian Internet use survey, household access to the Internet at home, by household income quartile, Canada and provinces. CANSIM (database). (Retrieved August 5, 2014)

Susaeta, A., Alavalapati, J., Lal, P., Matta, J. R., & Mercer, E. (2010). Assessing public preferences for forest biomass based energy in the southern United States. *Environmental Management*, *45*, 697-710.

Tolko Industries Ltd. (2014). Annual harvest and renewal plan: operating plan. Retrieved January 17, 2015 from http://www.tolkomanitoba.com/AOP.htm.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica, 48*, 817-838.

Chapter 3: Incorporating latent variables in choice models: The case of poplar biotechnology preferences in Alberta, Canada

3.1: Introduction

In light of recent developments in biotechnology research, such as genomics or genetic modification, numerous authors have examined public opinion of a wide range of biotechnology applications. While an understanding of public opinion towards different biotechnology applications has been developed, drivers of preferences are often unclear, and inconsistent results exist between different samples, studies, or contexts (Costa-Font et al. 2008; Pin & Gutteling 2009). This lack of clarity is especially present when dissecting how observed characteristics of individuals, such as socio-demographics, relate to preferences for, or acceptance of, biotechnology. One solution to provide further clarity on this issue is to use unobservable individual-specific characteristics, such as attitudes, perceptions, or values, as explanatory variables of biotechnology preferences or acceptance.

Attitudes are a type of latent variable, which means they have hidden realizations and must be inferred from one or more observed variables, known as indicators[4] (Skrondal & Rabe-Hesketh 2004). Typically, attitudes are measured by Likert scales, which consist of a series of statements that respondents rate their level of agreement with, using an ordinal response-format (DeVellis 2003). When inferring an underlying attitude from a series of indicators (Likert scale items), measurement error of the attitude is inherent in the process, as indicators are only an approximation of their underlying factor. However, it is common for researchers to specify attitudes as observed variables, calculated as the sum or mean of responses to Likert-type items, thereby implying no presence of measurement error in the variables. While there are numerous issues surrounding misuse or specification issues of Likert scales (see Jamieson 2004; Carifio & Perla 2007), Train et al. (1987) point out that failing to properly model latent variables with measurement error as covariates in choice models results in biased estimates in non-linear models.

[4] In economics and marketing literatures, utility is a commonly modeled latent variable, using an individual's stated or revealed choice between multiple alternatives as its indicator (Walker 2001).

Since choices, acceptance, and opinion are qualitative concepts, they are often coded in models as qualitative dependent variables (binary, ordered, or multinomial), implying that non-linear modeling is required. Based on the findings of Train et al. (1987), proper latent variable modeling techniques are especially crucial in studies of qualitative concepts. To reap the benefits of using attitudes or perceptions as explanatory variables of choices, researchers have combined latent variable and choice modeling methodologies in what are referred to as integrated choice latent variable (ICLV) or hybrid choice models (see Walker 2001; Temme et al. 2008; Gibson & Burton 2014). While the models are more parameter intensive than standard choice models, ICLV models simultaneously estimate latent variable and choice model equations; efficiently incorporating attitudes or perceptions in choice models while avoiding issues of parameter bias. Further, ICLV models allow researchers to test and model complex relationships between observed and latent individual-specific variables, providing greater explanatory richness.

This paper examines two issues: 1) how ICLV model results compare to choice models assuming no measurement error is present in attitudinal variables, and; 2) how attitudes affect preferences for forest biotechnology policy preferences. Using a stated preference choice experiment (SPCE) data surrounding poplar-breeding strategies collected from Albertan citizens, relationships between attitudes and forest policy preferences will be examined. Using SPCE responses between different forest policies as the dependent variable in choice models, attitudes will be incorporated into the model using two different methods. In one model, attitudes are assumed to be free of measurement error. The second model will use ICLV methodology, which properly specifies attitudinal variables and accounts for their measurement error.

This paper makes two contributions. First, the ICLV model will be compared to the worst-case scenario of incorrectly specifying attitudes in a choice model, where attitudes are treated as observed variables that are simply calculated as the average of response scores to their indicators. While other studies have examined the impact of specifying latent variables as observed (Gibson & Burton 2011), they have focused on more sophisticated latent variable modeling techniques to score attitudes or perceptions, and treated the calculated scores as observed variables. Second, to the best of the author's knowledge, no other studies have examined how attitudes relate to forest biotechnology or tree-breeding preferences, nor used a SPCE format to elicit these preferences.

3.2: Literature Review

Stated preference choice experiments are often used to measure preferences for goods or policies when revealed preference data is not available. It is theorized that one's choice between multiple alternatives is a manifestation of their preferences, so choice modeling allows for preferences for specific attributes of a good or policy to be inferred from choice data. SPCEs examining preferences for policies often present respondents with repeated choice questions between the current policy and a new proposed policy, in which they are asked to vote for their preferred policy in a referendum format (Boxall et al. 2012; Gibson & Burton 2014). A variety of potential new policies with different attributes are evaluated one at a time versus the current policy, allowing the researcher to understand how particular policy attributes affect respondents' vote choices in the context of tradeoffs between attributes. A major drawback of stated preference methods is the potential for bias arising from the hypothetical nature of the preference elicitation methods (Murphy et al. 2005). However, there is evidence that a binary, referendum approach is effective in predicting real referendum voting behavior and is incentive-compatible (Vossler et al. 2003; Carson & Groves 2007).

The process of modeling choices is sometimes likened to a black box, in which observed variables (attributes of the good or policy and observed respondent-specific characteristics, such as socio-demographics) are inputs, respondents' choices are outputs (Walker 2001), and preferences are inferred from this process. While this process measures the degree to which certain attributes of a choice alternative are preferred over others, or how demographic characteristics are linked to preferences for different alternatives or attributes, it lacks clarity in the underlying decision-making processes of individuals. For instance, choice modeling may determine preferences held by certain segments of a population, but not why or how these preferences came to be. The inclusion of attitudes in choice models, as facilitated by the ICLV model, can help clarify underlying determinants of choices.

The ICLV model is composed of three sub-models: the choice model, a measurement model, and a structural model. A generalized version of the choice sub-model of the ICLV model is represented by equation 1. According to economic theory, individuals seek to maximize utility (U). Assuming a binary choice format, U is measured as the utility associated with choosing observed response $C=1$ over $C=0$. Thus, if utility is positive, the choice model predicts that the respondent will choose *C=1*, and *C=0* will be observed if utility is negative. Utility is a function of observed individual-specific characteristics (*X*), attributes of the choice alternatives (*A*), latent individual-specific characteristics (attitudes) (η), and a series of unknown parameters (θ), while ε is a residual term.

$$U = f(X, A, \eta; \theta) + \varepsilon \quad (1)$$
$$where\ C = 1\ if\ U \geq 0, and\ C = 0\ otherwise.$$

Since attitudes (η) are a latent construct, they must be inferred from a set of observed variables known as indicators (Kline 2011). Most commonly, Likert scales are used to measure attitudes, which are a form of psychometric scale (DeVellis 2003). A Likert scale is usually comprised of a series of Likert-type items related to a single underlying factor (such as an attitude). Likert-type items are typically statements which respondents state their level of agreement with using an ordinal response-format, ranging from *strongly* agree to *strongly disagree.* In order for a latent attitudinal variable to be added to a choice model, certain conditions and assumptions must be met to ensure the latent construct is properly measured.

Two important properties that determine the quality of a latent construct are its validity and reliability (Kline 2011). Validity refers to how well a scale is measuring what it intends to measure, and can be assessed by expert opinion, or testing whether the latent construct exhibits relationships with external variables as suggested by theory. Reliability refers to the degree to which a construct is free from measurement error, as determined by shared covariance or correlation of its indicators. Most often, internal consistency reliability is measured by reporting Cronbach's alpha (Kline 2011). Reliability is linked to the degree to which indicators of a construct are uni-dimensional. A higher internal consistency reliability coefficient implies that less measurement error is present in a reflective latent construct (Kline 2011). As a baseline, alpha coefficients near or above 0.7 imply a latent variable is suitable for estimation, whereas a coefficient less than 0.5 implies that more variation across indicators is due to random error than the underlying attitude (Kline 2011). It is stressed that notions of validity and reliability are sample and context dependent, and should therefore be evaluated each time a latent construct is measured (Jarvis et al. 2003; Kline 2011).

Attitudes are frequently thought to be reflective latent constructs, which implies responses to indicators reflect the attitude being measured (Jarvis et al. 2003). If a latent attitudinal variable is reflective, it is implied that the underlying attitude being measured is causal of individuals' responses to its indicators. For the notion of reflectiveness to be true, it is expected that indicators will covary with each other (therefore implying internal consistency), share a common theme, and are manifestations rather than defining characteristics of the latent construct (Jarvis et al. 2003). Reflectiveness implies that individuals' attitudes are causal of their responses to indicator questions. Formative latent constructs, which are caused by their indicators, may also be modeled within an ICLV framework, but require different modeling structures and assumptions.

If a latent construct measuring an attitude meets the conditions listed above, it can be represented by equation 2, which is known as the measurement sub-model of the ICLV model (Walker 2001). Typically, the latent variable portion of ICLV models are specified as a Multiple Indicator Multiple Causes (MIMIC) model, where the latent factors are causal of their indicators (a measurement model represented by equation 2), and observed individual-specific variables are causal of the latent factors (a structural model represented by equation 3) (Jöreskog & Goldberger 1975). In equation 2, y_{ij} is a series of i observed indicators reflecting latent attitude j, ϕ is a series of unknown regression parameters, and ω_{ij} is a residual in the regression of y_{ij} on η_j. In order to identify η_j, the regression parameter linking y_{1j} to η_j is fixed equal to one for each latent attitude j, while parameters for all other indicators are freely estimated (Skrondal & Rabe-Hesketh 2004). That is, the regression slope between a latent variable and one of its indicators must be fixed.

$$y_{ij} = g(\eta_j; \phi) + \omega_{ij} \tag{2}$$

Last, is the structural sub-model of the ICLV model, which estimates relationships between X and η_j, represented by equation 3.

$$\eta_j = h(X; \psi) + \mu_j \tag{3}$$

In this equation, attitudes are specified as a function of observed individual-specific characteristics, where ψ is a series of parameters relating X to η_j, and μ_j is a residual term. Typically, η_j is assumed to be normally distributed, and a linear relationship between X and η_j is modeled (Walker 2001). The structural sub-model adds explanatory richness to the model, allowing observed individual-specific characteristics to affect utility, and thus the observed choice, as mediated through the latent attitudinal variables. Mediated effects are also known as indirect effects, and are equal to the product of the effect of the observed variable on the latent variable and the effect of the latent variable on utility (Kline 2011). The total effect of an observed variable on utility is the sum of direct and indirect effects of *X* on *U*.

Figure 3.2.1 provides a visual representation of the ICLV model, as determined by equations 1-3.

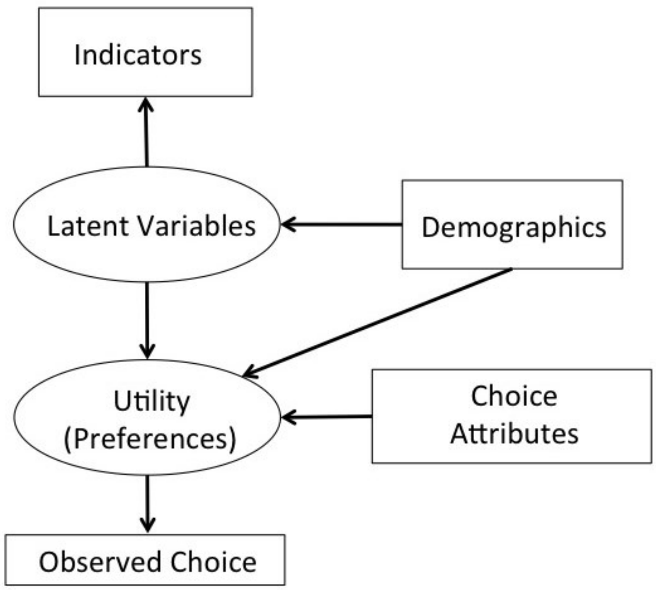


Figure 3.2.1 - Visual explanation of equations 1-3, representing the ICLV model: a choice model incorporating latent attitudinal variables. Adapted from Walker (2001).

Past research on ICLV models has provided numerous examples of different approaches to including attitudes in choice models; where most differences exist with respect to equations 2 and 3, and whether or not the equations are estimated simultaneously. In early examples of ICLV models, two-step estimation was employed due to software and computing limitations, including unbiased but inefficient estimation approaches (e.g. Morikawa et al. 2002). Most commonly within the ICLV literature, responses to indicators in equation 2 are specified as continuous variables due to software limitations in past years (Walker 2001; Ashok et al. 2002; Hess & Beharry-Borg 2012). However, recent developments have allowed for indicator responses to be modeled as ordered categorical variables, where a series of thresholds or cut-off variables are also estimated within an ordered probit or logit framework (Temme et al. 2008; Daly et al. 2012; Gibson & Burton 2014). This method may reduce specification errors, as responses to Likert-type indicators are measured on an ordinal scale rather than a continuous scale.

Various two-stage factor-scoring approaches that do not correct for parameter bias have also been used to measure latent attitudes to be included as covariates in choice models. Factor-scoring simply refers to the method used to determine individuals' levels of a latent variable, and a wide range of complexity in methodology is used by different authors (DiStefano et al. 2009). Parameter bias arises in ICLV models employing simplistic factor scoring approaches because the probability of a specific choice outcome is non-linear in the assumed distribution of the latent attitude (Train et al. 1987). Thus, specifying an estimated or expected value of an attitude as an observed covariate in a choice model introduces bias.

The simplest, and perhaps most common, approach of factor-scoring involves simply summing or averaging indicator responses where no estimation methods are involved, and only equation 1 is estimated (e.g. Hosseini-Matin et al. 2012; Marciano et al. 2014; Roosen et al. 2015). The downfall of this approach is the assumption that all indicators play an equal role in inferring the latent attitude, which may be refuted by factor analysis or other modeling results (DiStefano et al. 2009). Typically, this approach is only recommended for exploratory latent variable analysis (Hair et al. 2006) when evidence surrounding reliability and validity has not or cannot be evaluated. Further, this approach does not involve structural relationships between latent and observed individual-specific variables, and therefore provides less explanatory power. If the goal of a study is to identify which individuals hold specific preferences based on observed characteristics, single-equation modeling approaches do not allow for indirect effects mediated by attitudes, and effects of X on the choice outcome are estimated while controlling for η.

A more sophisticated method of measuring attitudes involves estimating factor scores via factor analysis, which may then be used as an observed covariate in the choice model to more accurately model the relationships between each indicator and the latent attitudes (DiStefano et al. 2009). Gibson and Burton (2011) used a two-stage, factor analysis approach where indicators were specified as ordered variables to examine the effect of assuming latent attitudes are free of measurement error in a choice model, but found no significant difference in results between willingness-to-pay estimates derived from this model and an ICLV model. To the best of the author's knowledge, no studies have compared parameter estimates between an ICLV model and a choice model including latent variables using more simplistic factor-scoring techniques, such as averaging responses to indicator questions.

3.3: Case Study: Public Preferences for Poplar Biotechnology in Alberta, Canada

3.3.1: Background

Genomic and tree-breeding research has been conducted in hopes of achieving a variety of desired outcomes, including pest-resistance, climate-change adaptation, or increasing wood quality and volume (Genome Canada 2014). One specific project, POPCAN, aims to harness genomic information to improve the suitability of poplars[5] as a cellulosic biofuel feedstock via multiple generations of breeding (Genome British Columbia 2014). In 2010, the Government of Canada mandated that a minimum of 5% of gasoline for transportation vehicles comes from renewable sources on average (Minister of Justice 2013) in an effort to mitigate greenhouse gas emissions. To provide a wider range of inputs in maintaining the minimum renewable fuel requirements, Canada may need to look beyond agricultural biofuel sources, and forest resources could become a contributor. However, 93% of Canadian forested land is publicly owned, which is subject to regulations regarding the types of trees that may be planted (Natural Resources Canada 2012). Due to public land regulations, many tree-breeding research projects are often unable to realize widespread application under current policy conditions[6]. As the application of POPCAN research, as well as other forest genomic research, would likely need to occur on public land and require public land policy change to become a reality, public evaluation of the technology is one of many factors to consider moving forward.

Many studies have evaluated public opinions of biotechnology applications, such as food or medicine (Costa-Font et al. 2008; Pin & Gutteling 2009), but few have focused on forestry. Further, links between preferences and respondent-specific characteristics are often statistically

---

[5] In this paper, the term "poplar" represents trees of the *Populus* genus, which includes poplar, aspen, and cottonwood.

[6] Specifically, most provinces require that trees planted on public land come from seed collected within a certain range of the planting site. Alberta has 90 defined seed zones (Alberta Environmental and Sustainable Resource Development 2009). Some breeding programs may not be feasible under this system, as each zone is subject to a small breeding pool, and would require some degree of unique research.

insignificant, and often vary in direction across studies when significant (Costa-Font et al. 2008). In a study of public acceptance of different tree breeding, biotechnology, and reforestation strategies aimed at climate-change adaptation, Hajjar et al. (2014) found few instances where results were explained by demographic characteristics. To address the lack of clarity in explaining public opinion of biotechnology in the food and medicine literature, many have relied on attitudes or perceptions as explanatory variables (Costa-Font et al. 2008; Pin & Gutteling 2009). However, to the best of the author's knowledge, no studies have examined attitudes as drivers of preferences for forest biotechnology.

3.3.2: Attitudes Affecting Forest Biotechnology and New Technology Preferences

Two types of latent attitudes or perceptions are most often used to explain preferences for a new policy or technology. Most often, attitudinal scales directly relating to perceptions of the biotechnology application being studied are used. For instance, when modeling GM food purchase or consumption decisions, Likert scales measuring attitudes towards GM food are often used as explanatory variables (e.g. asking whether respondents perceive GM food as beneficial, risky, or harmful) (Costa-Font et al. 2008; Costa-Font & Gil 2009; House et al. 2004). A potential issue with this approach is that causality is unclear in some cases, as one's prior opinion of a technology could be influencing their answers to attitudinal questions (Pidgeon & Poortinga 2006). This finding implies that attitudes measured in reference to choice alternatives or attributes may be endogenously determined by an individual's choice, resulting in inconsistent and biased estimates. Some studies have avoided using scales specific to the technology being examined, and instead focus on more general attitudes that are not dependent on the choice attributes or topic for which opinion is being measured (Lusk & Coble 2005; Costa-Font & Gil 2012), avoiding issues of uncertain causality.

Most discussion surrounding the causal structure of attitudes with technology acceptance is in the trust literature (Eiser et al. 2002; Poortinga & Pidgeon 2006). In general, higher levels of trust in groups involved with a biotechnology are thought to cause higher levels of biotechnology acceptance and perceived benefits, and lower levels of perceived risks (Siegrist 2010; Costa-Font & Gil 2009). However, the associationist view of trust refutes the causal link from trust to acceptance, theorizing that individuals respond to questions relating to trust in groups involved with a technology based on their prior opinion or acceptance of the technology

(Eiser et al. 2002; Poortinga & Pidgeon 2006). For this reason, the authors caution against using attitudes evaluated directly within the context of the technology being evaluated. Johanssen et al. (2006) also briefly mention this issue in a study of the effect of environmental attitudes on transportation mode choice, and address it by using responses to a series of questions about pro-environmental behaviours (such as recycling) as indicators.

Some studies have found that broader attitudes, such as those toward the environment or science, affect perceptions or acceptance of biotechnology. In a study of British Columbians' perceptions of forest biotechnology risk, those with higher biocentric and lower anthropocentric attitiudes perceived higher levels of risk (McFarlane 2005). Anthropocentric members of the public are thought to view nature as a wealth of resources serving humans, whereas biocentric people place a higher emphasis on aesthetic, spiritual, or passive uses of nature (Steel et al. 1994; McFarlane 2005). The public's attitudes toward science have also been negatively linked to perceived benefits of GM foods (Costa-Font & Gil 2012). In European studies, people with positive attitudes toward science perceived higher benefits or lower risks associated with GM food (Bredahl 2001; Costa-Font & Gil 2009; Costa-Font & Gil 2012).

The role of knowledge in determining acceptance of biotechnology has been of particular interest, perhaps due to generally low levels of both public knowledge and acceptance (Gaskell et al. 2003). Knowledge of science or a technology is generally positively correlated with its acceptance (Bak 2001; Sturgis et al. 2005), but the underlying reasons are unclear. The positive relationship between knowledge and acceptance of science and technology gave rise to the deficit model. The deficit model theorizes that a lack of support for science and technology is due to a lack of public knowledge, and that increased education will lead to higher acceptance (Gaskell et al. 2003). Further, the deficit model implies that ignorance, misinformation, or a lack of scientific understanding explains public opposition to new technologies. One key issue of the deficit model is the difficulty understanding how knowledge and support of science are related. It is possible that support for science results in further interest and engagement, although the same could also apply to those who view applications of science and technology as highly problematic or risky (Gaskell et al. 2003).

3.3.3: Questionnaire Design

Questionnaire design involved multiple stages of consultation with scientific experts (geneticists, botanists, and forest scientists) and the general public. First, four focus groups were held to assess the public's understanding of the questionnaire topic and to present an early draft of hypothetical referendum questions, which outlined attributes and impacts of various policy options relative to the current policy. Participants for all public focus groups were recruited using random-digit-dialing by Advanis Inc., an Edmonton-based market research firm. Two focus groups each were held in Edmonton, Alberta (16 participants) and Grande Prairie, Alberta (17 participants). Next, a survey was sent to a group of forestry experts to gather data on predicted changes in poplar growth rate and value arising from different breeding methods and allowing breeding stock to be chosen from anywhere in the world. Draft scenarios for hypothetical referenda were developed based on the expert estimates of increases in growth and value of poplars using different breeding methods. A discussion was then held with a group of experts involved with POPCAN (Genome British Columbia 2014) to ensure the information provided in the questionnaire was accurate.

Following further reviews, a final round of public focus groups was held, with two groups held in Edmonton, Alberta (24 participants) and North Battleford, Saskatchewan (22 participants). This round of focus groups aimed to ensure that all elements of the questionnaire were understood, and to reduce potential sources of bias. After completing these phases and resulting edits to the questionnaire, a pre-test version was administered online to 102 members (51 Albertans and 51 British Columbians) of an internet panel maintained by Ipsos Canada, a market research firm. The finalized survey contained four parts. First, Likert scales measuring attitudes were presented. Second, background information on poplars, biofuels, tree breeding methods, and Alberta's forest composition, industry, and policy was provided. Next, a series of hypothetical referendum questions were presented with follow-up questions, and demographic information was collected last.

Most Likert-type items measuring attitudes were answered using a 5-point ordered-response format ranging from *strongly disagree* to *strongly agree*, with a neutral mid-point. The majority of research combining stated preference tasks with latent variables focus on measuring respondents' attitudes or perceptions of the attributes used in the choice experiment (for examples, see Gibson & Burton 2014; Hess & Beharry-Borg 2012). However, it seems probable that latent constructs formed by asking respondents' opinions of choice experiment attributes may not be exogenous to the choice outcome. Poortinga & Pidgeon (2006) note that when measuring public acceptance of a technology, some people may respond to indicator questions (such as perceived risks) based on their previously determined stance regarding the technology. To reduce this possibility, only latent constructs measuring more general attitudes were measured, and were presented prior to the information and choice experiment sections to decrease the odds of respondents evaluating attitudinal items with the choice experiment topic in mind. Prior to the information section respondents were only told that the questionnaire focused on forest management, with no mention of biotechnology.

Scales measuring respondents' attitudes toward science, environmental attitudes, trust in various agencies, and knowledge of forestry and biotechnology were included in the survey. Respondents' attitudes toward science were measured using a 7-item Likert scale developed by Bauer (2000). Environmental values were measured by the 15-item New Ecological Paradigm scale (Dunlap et al. 2000). Trust in the federal government, provincial government, industry, scientists, and environmental non-government organizations were each measured using a four-item scale developed by Lang & Hallman (2005). Knowledge of forests and forest management was measured by six indicators compiled by McFarlane & Boxall (2000). Biotechnology knowledge was measured using a scale of 10 items from the Eurobarometer 58.0 questionnaire (Gaskell et al. 2003).

In total, six proposed policy scenarios were created for the referendum tasks. The six proposed policy scenarios were driven by two key attributes: the tree breeding method employed, and whether or not poplars would be used for biofuel production. Three breeding methods examined are traditional selective breeding (*trad*), genomics-assisted breeding (*genome*), and genetic modification *(GM*). Each breeding method appeared in one proposed policy scenario including biofuel production (referred to as *trad + BF, genome + BF, and GM + BF*) and another with no resulting biofuel production (referred to as *trad no BF, genome no BF,* and *GM no BF*). Each voting scenario was set up as a provincial referendum, where respondents were asked to vote for either the new proposed policy, or to stay with the current policy.

An example referendum question is presented in Figure 3.3.1. In addition to the breeding method and biofuel production policy attributes, supplemental information was presented for each referendum question. The additional information selected was based on focus group discussions during the survey development phase. First, improved poplar breeding details were presented in terms of parent tree source and breeding method. All proposed policies (right-most column) involved worldwide seed selection for improved poplars, while the current policy involved a small amount of selectively bred poplars (on less than 0.1% of land) using local breeding stock to represent breeding trials in Alberta. Next, estimates of commercial public forest land-use were provided, comprised of non-harvested forest (forest land falling within a Forest Management Agreement area with no future harvest plans), and land with harvested coniferous trees, natural poplars, and improved poplars. In the referendum exercise, harvested coniferous treed land was held constant for the current and all proposed policies. Harvested natural poplar land refers to harvested land regenerated naturally via roots and seeds of harvested poplars. Impacts of proposed policies on industry were included with three possible categories depending on the gains associated with different breeding methods: small, moderate, and strong positive impacts. Carbon emission reductions arising from replacing gasoline with poplar-derived biofuels were represented by the estimated equivalent in cars driven per year.

Current commercial forest land-use was calculated based on data from Alberta Environment and Sustainable Resource Development (2013). Predicted changes in land-use arising from allowing different breeding methods and worldwide seed selection on public land were determined using simulation results from Anderson et al. (2012). All policies assumed an equal annual-allowable-cut (AAC), implying the same volume of timber would be harvested in each scenario. Technically, higher tree growth rates could imply a higher annual-allowable-cut (AAC) instead of leaving some areas unharvested; but a constant AAC is assumed to avoid confounding the area planted to genetically improved poplars with different tree breeding methods. The impact of allowing new tree breeding methods on the forest industry (jobs and income) was estimated using a combination of results from Anderson et al. (2012), the expert tree growth and value survey, and forest industry composition in Alberta (proportion of hardwood to softwood production from Natural Resources Canada (2009) and current land-use). Reduction in carbon emissions per year is based on 5% of Alberta's gasoline being replaced by Poplar-derived biofuel, using a low (65-70%) estimate of life-cycle analysis carbon emission reduction of second-generation biofuels from Schmer et al. (2008), and gasoline consumption data from Statistics Canada (2013). Since little previous research exists on public approval of different tree breeding methods, we aimed to keep voting exercise simple and limit the number of new policies. Thus, while it could be informative to allow land-use, impact on industry, and changes in carbon emissions to freely vary in the choice experiment, these attributes are strictly correlated with the breeding method and biofuel production attributes for the sake of simplicity.

Policy and Management Features	Current Policy and Management Approaches	New Policy and Management Approaches
"Improved" Poplars On Commercial Public Forest Land in Alberta		
Region where parent trees are located	Parent trees come from the same region as regenerated trees	Parent trees can come from any location
Breeding method	Traditional breeding using observed traits	Breeding assisted by genetic information (DNA markers)
How commercial public forest land in Alberta is used	 Non-Harvested (40%) Harvested Coniferous Trees (40%) Harvested Natural Poplars (20%) Harvested "Improved" Poplars (less than 0.1%)	 Non-Harvested (48%) Harvested Coniferous Trees (40%) Harvested Natural Poplars (9%) Harvested "Improved" Poplars (3%)
Impact on forest industry in Alberta (jobs and income)	No change	Moderate positive impact
Reduction in carbon emissions in Alberta from using poplar biofuels	None	Equivalent to 120,000 cars off the road per year in Alberta

Above each table, the text, "Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?" appeared.

Figure 3.3.1 – Example of a hypothetical referendum question (*Genome + BF* scenario) used to measure public preferences for using different Poplar breeding technologies for use on public land.

Policy attribute levels used in the hypothetical referenda are listed in Table 3.3.1. Each proposed policy is defined by its breeding method and whether poplar-derived biofuel production occurs. Thus, the three proposed policies with no poplar-derived biofuels are titled as *trad no BF* (traditional breeding), *genome no BF* (genomic-assisted breeding), *GM no BF* (genetic modification), and the three proposed policies involving poplar-derived biofuel production are *trad + BF, genome + BF,* and *GM + BF*. In the choice experiment, each respondent evaluated all six proposed policies versus the current policy. Thus there was no experimental design required to develop choice sets in the referenda tasks.

Table 3.3.1 – Outline of policy attributes for different forest biotechnology policy and management approaches used for the stated preference choice experiment.

	Policy Attribute			
Policy Scenario	Non-Harvested Commercial Forest Land	Land Planted to "Improved" Poplars	Positive Impact on Industry	Reduction in Carbon Emissions (Cars per Year)
Current Policy	40%	Less than 0.1%	-	-
Proposed Policies:				
Trad no BF	46%	3%	Small	0
Trad + BF	46%	3%	Small	120,000
Genome no BF	48%	3%	Moderate	0
Genome + BF	48%	3%	Moderate	120,000
GM no BF	49%	3%	Strong	0
GM + BF	49%	3%	Strong	120,000

3.3.4: Questionnaire Administration

The questionnaire was administered online to members of an internet panel maintained by Ipsos Canada, a market research firm. The goal was to obtain a representative sample of the Alberta population[7]. Using an online format allowed for color graphics in the information and hypothetical referendum sections, randomized orders of hypothetical referendum questions, and providing a hyperlink to information and definitions when answering choice questions. The internet panel maintained by Ipsos Canada consists of over 200,000 members actively maintained to be representative of the Canadian population based on demographic information. Participants were recruited with quotas on age, gender, and municipality population to increase each province's sample representativeness of its population demographics. To decrease sampling bias within the panel, respondents were provided with an incentive from Ipsos Canada, and were not informed of the study topic when invited to participate. Internet surveys may face issues of

[7] In total, 4 provinces (Alberta, British Columbia, Manitoba, and Saskatchewan) were sampled. This study focuses on the Alberta sub-sample.

sampling bias, as internet access is a requirement. However, an increasing proportion of Canadians are accessing the internet at home over time. In 2012, 83% of Canadians had internet access, an increase from 79% in 2010 (Statistics Canada 2013).

3.3.5 Statistical and Econometric Methods

The econometric specification closely follows that of Gibson & Burton (2014), but with a binary probit specification for the vote choice equation and multiple responses per respondent. Equation 4 represents the binary choice model for respondent *n* evaluating choice m. Economic theory posits that individuals seek to maximize utility, and will therefore choose the policy that makes them best off. With a binary dependent variable, where the observed choice C_{nm} = 1 implies a vote in favor of a proposed policy, and C_{nm} = 0 implies a vote for the current policy, U_{nm} then denotes the latent utility associated with voting in favor of a proposed policy over the current policy.

$$U_{nm} = \tau + \beta'^{X_n} + \Lambda'\eta_n + \gamma' A_m + u_n + \nu_{nm}, \quad (4)$$

where C_{nm} = 1 if $U_{ij} \geq 0$, and C_{nm} = 0 otherwise.

In equation 4, the variables and coefficients are defined as follows:

- C_{nm} is the observed vote choice (1 = new policy, 0 = current policy);
- U_{nm} is the utility of voting for a new policy versus the current policy;
- τ is a constant;
- X_n is a vector of L observed respondent-specific variables (demographics);
- η_n is a vector of *J* unobserved latent attitudinal variables;
- A_m is a vector of *M* observed variables associated with choice scenarios. Specifically, there are dummy variables for breeding method (molecular markers and genetic engineering) and biofuel production;
- u_n is a respondent-specific error term;
- ν_{nm} is a normally distributed error term;
- β, Λ, γ are vectors of coefficients to be estimated.

There are *J* latent variables (η_{nj}), and *I* indicator responses for latent variable j (y_{nij}). Responses to indicator questions were recorded using an 5-point ordinal response format, so the latent variables and indicator responses are linked via a series of ordered probit models. For this reason, both a measurement model (equation 5 below) and threshold model (equation 6 below) are involved. Since the latent variables are thought to influence one's responses to *I* indicator questions, each latent variable is regressed on a series of *I* latent indicator responses (y^*_{nij}). In equation 5, α_{ij} is the constant in the equation for indicator i of latent variable j, Γ_{ij} is the coefficient linking the latent variable to the latent indicator response, and ε_{nij} is a mean-zero random error term. If an indicator does not belong to set j, the relationship between the latent variable and indicator is restricted to equal zero (that is, we assume no relationship between an indicator for trust and the science attitude latent variable). In equation 6, the observed indicator responses are predicted by their latent indicator responses and a series of 4 threshold estimates (κ_{ij1} to κ_{ij4}).

$$y^*_{nij} = \alpha_{ij} + \Gamma'_{ij}\eta_{nj} + \varepsilon_{nij} \tag{5}$$

$$y_{nij} = \begin{Bmatrix} 1\ if & & y^*_{nij} \leq \kappa_{ij1} \\ 2\ if & \kappa_{ij1} < & y^*_{nij} \leq \kappa_{ij2} \\ 3\ if & \kappa_{ij2} < & y^*_{nij} \leq \kappa_{ij3} \\ 4\ if & \kappa_{ij3} < & y^*_{nij} \leq \kappa_{ij4} \\ 5\ if & \kappa_{ij4} < & y^*_{nij} \end{Bmatrix} \tag{6}$$

$$\eta_{nj} = \delta_j + \lambda'_j X_n + w_{nj}, w_{nj} \sim N(0, \varphi_j) \tag{7}$$

Equation 7 represents the structural model, which relates the latent variables to the respondents' demographic characteristics. Each latent variable is continuous with a normal distribution, so the structural model is estimated by a set of J linear regressions. In equation 7, δ_j is the constant in the equation for latent variable j, λ_j is a vector of parameters relating demographic characteristics to latent variable j, and w_{nj} is a vector of mean-zero random error terms in the estimation of η_{nj}. In order to identify the latent variables, $\Gamma_{1j} = 1$, all $\alpha_{ij} = 0$, and all $\delta_j = 0$, while all threshold terms are freely estimated (Skrondal & Rabe-Hesketh 2004). To illustrate the system of equations to be estimated, equations 4-7 and their linkages are mapped in Figure 3.3.2. In the figure: arrows imply causal paths between variables; double-ended arrows represent correlations; observed variables are represented by rectangles, and; latent variables are represented by ovals.

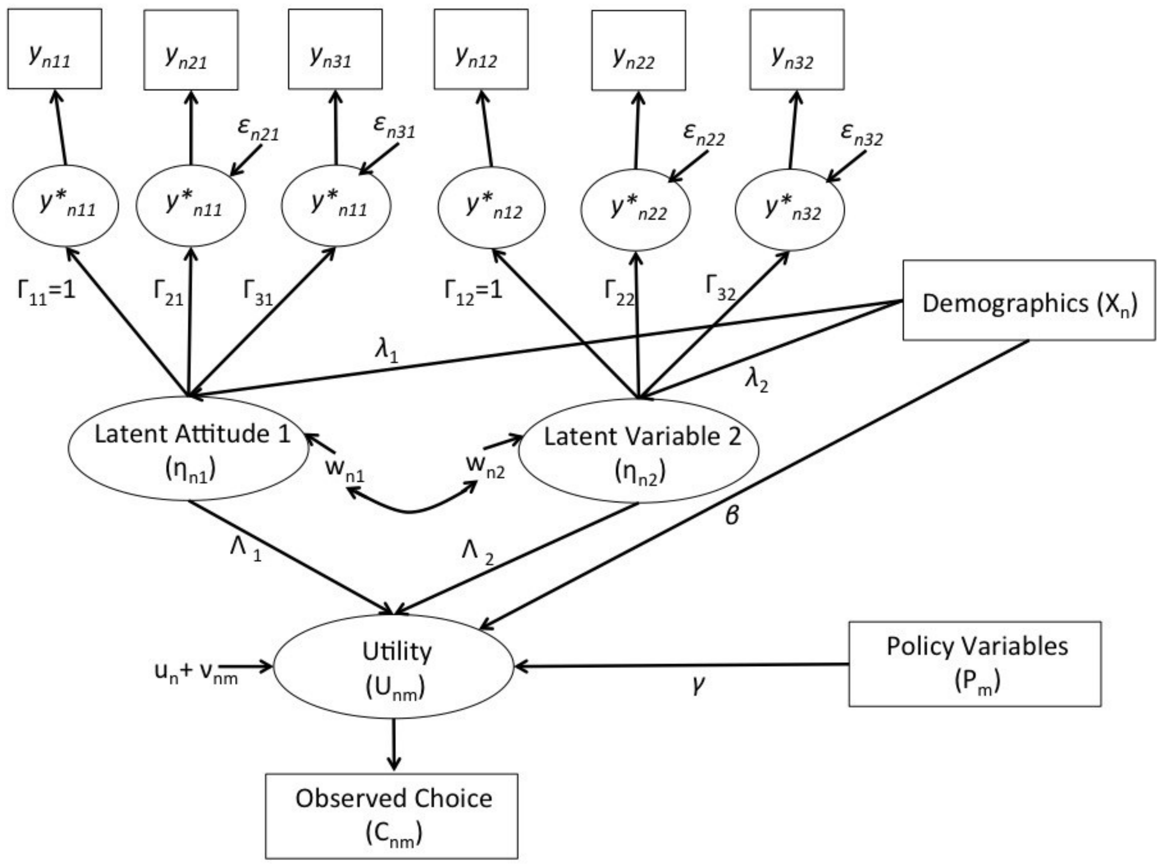


Figure 3.3.2 – Summary diagram of equations 4-7, outlining the integrated choice latent variable model determining forest policy choice.

There are a variety of statistical tests and fit indices that can be used to evaluate latent variable models, the results of which determine whether a model should be accepted or rejected. The most important test, the model chi-square statistic, examines whether the covariance matrix generated by the model is significantly different from the observed covariance matrix. If the model chi-square is statistically significant, the exact-fit hypothesis is rejected for the model, and is likely indicative of an incorrectly specified model. If the model chi-square is insignificant, it implies that the model covariance data is consistent with the observed covariance data, but does not strictly imply that a model should be accepted (Kline 2011). In some cases, very large samples (*i.e.* N=5000) may contribute to a rejection of the exact-fit hypothesis. However, Kline

(2011) points out that numerous studies with large samples have failed to reject the exact-fit hypothesis, and discourages researchers from claiming a rejection of the test is driven only by sample size without further investigation.

Kline (2011) also provides an overview of other useful, though less powerful tests. The root mean squared error of approximation (RMSEA) is a “badness”-of-fit index adjusted for parsimony. For a model to accept the close-fit hypothesis, the value of the RMSEA must be significantly less than 0.05, while values models with and RMSEA significantly greater than 0.1 accept the poor-fit hypothesis (Kline 2011). The comparative fit index (CFI) compares the degree to which model fit has improved in the estimated model in comparison to the baseline (or null) model, in which no parameters are freely estimated. It is suggested that models with a CFI less than 0.95 may be specified incorrectly, but that a CFI greater than 0.95 is not a sufficient condition for accepting a model (Kline 2011). Absolute fit indices, measuring the proportion of variance explained by the model, are also recommended to provide insight on the predictive power of the model (Kline 2011). In summary, each of the fit indices listed cannot be used as a single sufficient criterion that a model should be accepted, but they should be used collectively to detect whether a model may be flawed.

Poor fit statistics can be indicative of numerous issues in the model. Some of these issues are specific to latent variable modeling, including low internal consistency of latent variables, or strong cross-loadings of indicator responses between multiple latent variables, though this is not problematic in all contexts. Other issues may arise from high residual correlations or systematic patterns of smaller residual correlations among indicators.

To simultaneously estimate equations 4-7, a robust maximum likelihood estimator was employed using Mplus software (Muthén & Muthén 2007). Since each respondent answered multiple vote questions, the Huber-White sandwich estimator is used, which corrects for correlated errors between votes for each respondent; but errors between respondents are assumed to be uncorrelated (Huber 1967; White 1980).

The ICLV model will be compared to two other choice models. First, a choice model will be estimated following equation 4, but with latent attitudes (η) excluded. This model will be referred to as the Basic model. Second, equation 4 will be estimated, specifying the latent attitudes as observed covariates, thereby ignoring the measurement error of the latent attitudes.

This model will be referred to as the No ME (no measurement error) model. Latent attitudes in the No ME model were calculated as the sum of responses to their indicator questions.

3.4: Results

3.4.1: Descriptive Statistics

Table 3.4.1 lists descriptive statistics of the data with comparisons to the Alberta population where appropriate. For most socio-demographic characteristics, the sample of respondents is similar to the provincial population. However, exceptions are that the sample is more female and educated, and less urban than the greater Alberta population. Percentages of respondents voting in favor of each proposed policy are listed in the lower half of Table 3.4.1. Minimal differences are present in voting behaviour between the three policies involving no biofuel production. For policies involving biofuel production, *Trad + BF* is most preferred, and acceptance rates decrease as more technical innovation is involved with tree breeding.

Table 3.4.1 – Descriptive statistics of questionnaire data (N), compared with Alberta population statistics.

Characteristic	N	Pop.
Number of Respondents	1205	-
Male (%)	42	51
Average Age (18+)	48	45
Population of Centre of Residence (%):		
> 100,000	57	68
10,000 - 99,999	22	13
< 10,000	21	18
Post-Secondary Education Attained (%)	67	55
% Voting in Favor of Proposed Policy:		
Trad no BF	41	-
Trad + BF	65	-
Genome no BF	43	-
Genome + BF	64	-
GM no BF	44	-
GM + BF	58	-

Population education data from Statistics Canada (2012b); all other population data from Statistics Canada (2012a).

3.4.2: Psychometric Results

Table 3.4.2 lists results and descriptions of the final versions of psychometric scales used for further analysis. For each scale, some items were dropped on qualitative and quantitative grounds, based on a process outlined in Appendix 3. Each scale presented has a Cronbach's alpha coefficient greater than or equal to 0.7, which implies acceptable reliability (Kline 2011). The forestry knowledge scale was not further analyzed, due to low internal consistency reliability (α = 0.17), while the biotechnology scale seems to more effectively measure knowledge of GM, which is not relevant as a direct effect on voting behaviour. Given the data collected, it is possible to examine the validity of the trust in scientists, attitude toward science, and environmental concern scales by testing correlations. The total means of responses to the attitude toward science and trust in scientists scales are positively correlated (ρ = 0.42, S.E. = 0.01). While neither scale is being tested against some form of behaviour, this result supports the validity of both scales because it is likely that individuals who view science more positively would be more trusting of scientists. A polyserial correlation between the environmental concern scale and environmental organization membership is positive (ρ = 0.19, S.E. = 0.04), which implies that those who are members of an environmental organization exhibit higher levels of environmental concern. While these tests may not sufficiently ensure validity, they provide evidence that the scales are measuring the attitudes they intend to measure.

Table 3.4.2 – Results (mean responses to indicators and reliability, measured by Cronbach's alpha) and descriptions of final versions of psychometric scales analyzed.

Latent Attitude	Mean Response	α	Description
Trust in Industry	3.31	0.88	Evaluations of competence, doing the right thing for society, and honesty (3 indicators). Higher score implies more trusting.
Trust in Scientists	3.86	0.82	
Trust in Provincial Government	2.74	0.87	
Attitude Toward Science	3.35	0.70	Evaluations of science as being rational & unbiased, policy neutral, and being able to present a true picture of world (3 indicators). Higher score implies more positive attitude.
Environmental Concern (from NEP scale)	3.67	0.75	Perceptions of general, large-scale environmental risk, and humans' contributions to environmental risk (3 indicators). Higher score implies higher concern.

3.4.3: Model Results

Numerous preliminary models were tested to understand the relationships between the attitudinal variables and hypothetical voting behaviour. The preliminary models indicated that only trust in industry and attitude toward science are statistically significant direct determinants of voting choices at the 5% level. Trust in scientists is excluded from the final ICLV model, as it is collinear with attitude toward science and a weaker predictor of policy choice. Further, indicators of trust in scientists and attitude toward science have high residual correlations, which lead to estimation problems. Trust in provincial government is a statistically significant determinant of policy choice when trust in industry is excluded from the model, but is insignificant when both variables are covariates. Environmental concern has no direct effect on policy choice, nor does the entire 15-item NEP scale as a whole. This result is not supported by literature studying GM food preferences (Costa-Font et al. 2008; Costa-Font & Gil 2012), but may be explained by each proposed policy involving both an environmental risk (planting exotic trees on public land) and benefit (harvesting less land, or biofuel production). Due to the high number of parameters required to estimate each latent variable, only attitude toward science and trust in industry are included in the final ICLV model.

Fit statistics typically used to evaluate structural equation models are not readily available in MPlus using the robust maximum-likelihood estimator. Thus, latent attitudinal variables were first modeled separately to evaluate the measurement model, as recommended by Temme et al. (2008). Using a robust mean- and variance-adjusted weighted least squares estimator as recommended by Brown (2006) for categorical indicator data, a confirmatory factor analysis model was evaluated. The model only included attitudes and their indicators (equations 5 and 6), and all fit statistics met the recommended cutoffs (exact-fit hypothesis p-value = 0.4722, RMSEA = 0 (99.8% probability that RMSEA <0.05), CFI = 1.00, TLI = 1.00).

ICLV model results are presented in Table 3.4.3. Probit coefficients relating explanatory variables to the underlying utility associated with voting in favor of a proposed policy over the current policy are listed in the first section, labeled *Choice Model*. Within the choice model, the set of five binary policy variables are interpreted as the change in utility associated with voting for that specific proposed policy relative to voting for *Trad no BF* (the base case) in a separate vote. Next are the structural model estimates, linking observed respondent characteristics to the continuous latent attitudes. Last is the measurement model, displaying the relationships between psychometric indicators and their associated latent attitude.

Only two observed respondent-specific characteristics are significant determinants of the likelihood of voting in favor of a proposed policy in the choice sub-model. Older respondents are less likely to vote in favor of a proposed forest policy over the current policy, and those living in medium population centres (10,000-100,000) are more likely to vote in favor of a proposed policy relative to respondents living in large population centres. All policy variables but one are significant determinants of voting behaviour. All proposed policies ensuring biofuel production are more preferable than a proposed policy involving traditional breeding and no biofuels, but this effect decreases as the level of human intervention in breeding methodology increases. Respondents are more likely to support *GM no BF* over *Trad. no BF*, but view *Trad. no BF* and *DNA no BF* similarly. Both latent attitudes are significant positive determinants of voting in favor of a proposed policy, which is in line with results from GM food studies involving trust (Poortinga & Pidgeon 2006) and attitude toward science (Costa-Font & Gil 2012).

In the structural model, respondents who are male, older, or have a post-secondary education are less trusting of industry, while males and younger respondents exhibit more favorable attitudes toward science. In the measurement model, all indicators are significantly linked to the appropriate latent variable. Threshold parameters of indicators in the measurement model are presented in Appendix 4, as they do not aid in model interpretation.

Table 3.4.3 - ICLV model results for Alberta, with a choice model examining determinants of voting in favor of a proposed forest biotechnology policy over the current policy.

	Choice Model	
Variable	Coefficient	Std. Error
Constant	0.220*	0.115
Male	0.039	0.058
Age	-0.008**	0.002
Post-Sec. Education	-0.098	0.060
Pop. <10k	-0.071	0.072
Pop. 10k-100k	0.156**	0.070
Policy Variables		
Trad. + BF	0.644**	0.043
Genome No BF	0.052	0.037
Genome + BF	0.603**	0.045
GM no BF	0.098**	0.041
GM + BF	0.467**	0.045
Latent Variables		
Trust in Industry	0.064**	0.014
Attitude Toward Science	0.116**	0.035

	Structural Model			
	Trust in Industry		Attitude Toward Science	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Male	-0.681**	0.160	0.158**	0.073
Age	-0.012**	0.005	-0.005**	0.002
Post-Sec. Education	-0.526**	0.170	0.116*	0.070
Pop. <10k	-0.039	0.194	-0.002	0.085
Pop. 10k-100k	0.084	0.184	-0.124	0.082
Correlation (Trust Industry, Sci. Attitude)	0.135	0.091	-	-

	Measurement Model			
	Trust in Industry		Attitude Toward Science	
Indicator	Coefficient	Std. Error	Coefficient	Std. Error
Trust Ind. 1	1	-	-	-
Trust Ind. 2	1.351**	0.279	-	-
Trust Ind. 3	0.516**	0.058	-	-
Science Att. 1	-	-	1	-
Science Att. 2	-	-	1.973**	0.441
Science Att. 3	-	-	0.705**	0.077
Variance of Latent Attitude	5.224**	1.048	0.924**	0.168
McKelvey-Zavoina R^2 (Choice Model)		0.116		
# Respondents		1127		
(# Votes)		(6762)		
Log-Pseudo-Likelihood (Whole Model)		-54107.096		

** Indicates significance at or above the 5% level, * Indicates significance at or above the 10% level.

Perhaps of more interest than direct effects of observed respondent-specific characteristics on forest policy voting behaviour are the total and indirect effects, outlined in Table 3.4.4. Indirect effects measure the effect of an observed respondent-specific variable on choice, routed through latent mediating variables, and the total effect equals the sum of the direct effect and indirect effects. According to indirect effect estimates, males are less likely to vote for a proposed policy due to lower levels of trust in industry, but more likely to vote for a proposed policy because of more favorable attitudes toward science. However, these two effects cancel each other out, and gender does not have a statistically significant total impact on voting behaviour. Older respondents are less trusting of industry and hold less positive attitudes toward science, both of which contribute to a larger negative total effect on the likelihood of voting for a proposed policy over the status-quo. Respondents with post-secondary education are less trusting of industry, which indirectly causes a lower likelihood of voting in favor of a proposed policy. While the direct effect of post-secondary education on voting behaviour is insignificant, the total effect is significant and negative at the 10% level. No indirect effects are significant for population variables, though respondents living in medium-sized centres exhibit positive total effects due to the significant direct effect on utility associated with voting in favor of a proposed policy.

Table 3.4.4 – Total and indirect effects of observed respondent-specific characteristics on forest policy-voting behaviour for No ME Mediation and ICLV Models.

	Indirect Effect (Trust in Industry)		Indirect Effect (Science Attitude)		Total Effect	
Variable	Est.	SE	Est.	SE	Est.	SE
Male	-0.044**	0.013	0.018*	0.010	0.013	0.058
Age	-0.001**	<0.001	-0.001**	<0.001	-0.009**	0.002
Post-Sec. Educ.	-0.034**	0.012	0.013	0.009	-0.118*	0.060
Pop. <10k	-0.003	0.012	<0.001	0.010	-0.074	0.073
Pop. 10k-100k	0.005	0.012	-0.014	0.010	0.147**	0.073

** Implies significance at or above the 5% level.
* Implies significance at or above the 10% level.

Results from the Basic and No ME choice models are presented in Table 3.4.5. To evaluate explained variance for each choice model, a pseudo-R^2 developed by McKelvey and Zavoina (1975) is used. The McKelvey-Zavoina R^2 measures the variance of the underlying latent dependent variable (*U*; the utility associated with a respondent's vote choice) that is explained by explanatory variables. When comparing model results between the Basic, No ME, and ICLV models, the explained variance of choice increases when attitudes are included as covariates (from 8.4% in the Basic model, to 11.2% in the No ME and 11.6% in the ICLV model). Unfortunately, it is not possible to isolate the log-pseudo-likelihood of the choice sub-model from the ICLV model, so likelihood ratio and information criteria tests of model fit are not possible. However, the Bayesian information criterion (BIC) (Schwarz 1978) of the No ME model is superior to that of the Basic model, so it is likely that the choice model equation of the ICLV model is also preferable to the Basic model.

Table 3.4.5 – Binary probit model results for Basic and No ME choice models, assessing factors affecting the probability of voting in favor of a proposed forest biotechnology policy over the current policy.

	Model			
	Basic		No ME	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Constant	0.218*	0.114	0.133	0.116
Male	0.013	0.057	0.036**	0.057
Age	0.009**	0.002	-0.008	0.002
Post-Sec. Education	-0.116**	0.059	-0.098	0.060
Pop. <10k	-0.072	0.071	-0.066**	0.072
Pop. 10k-100k	0.144**	0.071	0.151**	0.070
Policy Variables				
Trad. + BF	0.633**	0.042	0.643	0.042
Genome No BF	0.051	0.037	0.052**	0.037
Genome + BF	0.593**	0.044	0.602**	0.045
GM no BF	0.096**	0.040	0.097**	0.041
GM + BF	0.459**	0.044	0.466**	0.045
Latent Variables				
Trust in Industry	-	-	0.135**	0.028
Attitude Toward Science	-	-	0.143**	0.037
Log-Pseudo-Likelihood	-4493.916		-4427.702	
# Votes	6762		6762	
# Respondents	1127		1127	
McKelvey-Zavoina R^2	0.084		0.113	
BIC	9084.843		8970.052	

When comparing coefficient estimates between the Basic, No ME, and ICLV models, one difference stands out. According to estimates from the Basic model and total effect estimates from the ICLV model, those with a post-secondary education are less likely to vote in favor of a proposed forest biotechnology policy over the current policy. However, the effect of post-secondary education is statistically insignificant in the No ME model (p = 0.101). This difference illustrates the benefit of the interesting modeled relationships between attitudes and observed variables in the ICLV model that the No ME model lacks. In the No ME model, attitudes strictly enter as covariates alongside post-secondary education, so the effect of post-secondary education is measured while controlling for attitudes. In the ICLV model, while the direct effect of post-secondary education is insignificant, the total effect is significant. The relevance of this issue depends on the context of the study. If a researcher wishes to estimate the effects of an observed variable while using an attitude as a control, this shortcoming of the No ME model is less relevant. If the goal of modeling is to identify which respondents are more likely to accept a new policy, the ICLV model is preferable. However, by estimating the direct and indirect effects, the ICLV model is capable of identifying both types of relationships, and is therefore superior to the No ME model.

To provide more meaningful interpretations of choice model estimates and compare estimates across models, marginal effects are presented in Table 3.4.6. All marginal effects were calculated at the means of explanatory variables, and are therefore evaluated as effects of deviations from the means. For continuous variables, marginal effects are interpreted as the percent change in likelihood of voting in favor of a proposed policy given a one-unit increase from the mean of an explanatory variable. In the case of latent variables, marginal effects are calculated based on a one standard deviation increase from the mean of the latent variable to account for scaling. For dummy variables, marginal effects are interpreted as the percent change in likelihood of voting in favor of a proposed policy relative to the excluded case. All marginal effects were calculated using the *model constraint* command in Mplus (Muthén & Muthén 2010), and standard errors were calculated using the delta method (see Greene 2008).

Table 3.4.6 – Total marginal effects of explanatory variables on forest policy vote choice derived from the Basic, No ME, and ICLV models.

	Model		
	Basic	No ME	ICLV
	Marginal Effect (Standard Error)		
Male	0.005 (0.023)	0.014 (0.023)	0.005 (0.023)
Age	-0.004** (0.001)	-0.003** (0.001)	-0.004** (0.001)
Post-Sec. Educ.	-0.046** (0.024)	-0.039* (0.024)	-0.047** (0.024)
Pop. <10k	-0.029 (0.029)	-0.026 (0.029)	-0.029 (0.029)
Pop. 10k-100k	0.057** (0.028)	0.060** (0.027)	0.058** (0.028)
Latent Variables			
Science Attitude	-	0.043** (0.011)	0.044** (0.013)
Trust in Industry	-	0.055** (0.011)	0.057** (0.013)
Policy Variables			
Trad. + BF	0.241** (0.015)	0.244** (0.015)	0.238** (0.014)
Genome no BF	0.020 (0.015)	0.020 (0.015)	0.020 (0.015)
Genome + BF	0.223** (0.016)	0.230** (0.016)	0.224** (0.015)
GM no BF	0.038** (0.016)	0.039** (0.016)	0.038** (0.016)
GM + BF	0.178** (0.016)	0.181** (0.016)	0.177** (0.016)

** Indicates estimates are significant at or above the 5% level.
* Indicates estimates are significant at or above the 10% level.

To compare marginal effect estimates between the ICLV model models with Basic and No ME models, Z-tests were used as recommended by Paternoster et al. (1998). The Z-tests indicated no significant differences in results are present, and are therefore not presented for brevity, as all estimates are highly similar. Gibson and Burton (2011) found similar results comparing willingness-to-pay estimates from an ICLV model to a model assuming no measurement error present in explanatory attitudinal variables. Similar to the coefficient estimate results in Table 3.4.5, the marginal effect estimate of post-secondary education is significant at the 10% level (p=0.100) in the No ME model, while it is significant at the 5% level in the Basic (p=0.049) and ICLV (p=0.048) models. Overall, it seems that the bias in parameter estimates of the No ME model in this study is not problematic enough to affect policy-relevant translations of model results. However, the No ME model is inferior to the ICLV model by not including regressions of attitudinal variables on observed respondent-specific variables. In fact, the largest differences in marginal effect estimates occur for observed respondent-specific variables with significant indirect effects estimated by the ICLV model. However, by allowing the indirect effects of observed variables to be mediated through attitudes, the ICLV model not only provides benefits in preventing Type II, and presumably Type I errors, but also provides greater explanatory richness.

3.6: Conclusion

This paper addressed two issues: to provide further understanding of how choice model results are affected by including latent attitudinal variables as covariates, and to understand how attitudes affect preferences for biotechnology and tree-breeding applications in forestry. Using a sample of the general public from Alberta, respondents were presented with choices between different policies involving different tree-breeding methods and associated outcomes in and SPCE exercise, and attitudinal variables were used to explain these choices. Using SPCE responses as the dependent variable, a choice model that specified latent attitudinal explanatory variables as observed variables (No ME model) was compared to an ICLV model, which accounts for measurement error in attitudinal variables.

When comparing estimates of the ICLV and No ME models, no significant differences were found, similar to the results of Gibson and Burton (2011). Gibson & Burton (2011) theorize that the underlying source of similarity of estimates between models was attributed to high measures of validity and consistency ($\alpha \geq 0.9$) of the latent attitudes used in their study. In this paper, the attitude toward science scale (Bauer et al. 2000) exhibited internal consistency near the recommended low-end cutoff ($\alpha = 0.7$) suggested for an acceptable reflective attitudinal scale, yet no significant difference in estimates between the ICLV and No ME models was detected. However, this result should be evaluated with caution when determining whether an approach ignoring measurement error of latent variables is appropriate. Latent attitudes with alpha coefficients below 0.7 were not included in the ICLV model, and scales with worse reliability are likely prone to greater measurement error. Thus, if the No ME modeling approach is used, researchers should carefully analyze scale reliability to minimize potential sources of bias. While no significant differences between models were found, the No ME model is prone to Type II errors when measuring effects of observed respondent-specific variables on policy choice, by separating the effects of observed and latent respondent-specific variables. The ICLV model avoids this issue by simultaneously regressing attitudinal variables on observed variables and providing indirect and total effects of observed variables. Depending on the direction of indirect and total effects, it is possible that Type I errors are also likely when no relationships between observed and attitudinal respondent-specific variables are modeled. This issue is most problematic when the researcher wishes to identify individuals' preferences based on observable characteristics, while gaining further understanding of preferences via latent traits. If the goal of including latent attitudes or perceptions in a choice model is to evaluate preferences while controlling for the latent trait, the faults of the No ME model are less problematic.

Though no notable differences in marginal effect estimates were detected from biased parameters in the No ME model when compared to the ICLV model, simulation studies investigating parameter bias are recommended for future research. Specifically, it would be of interest to determine the conditions under which significantly different estimates may be obtained between No ME and ICLV models. It seems that sources of biased or incorrect estimates stem from scale reliability and a lack of indirect or mediator effects in No ME models, so variation in these two factors may explain when different modeling methodologies are appropriate.

When evaluating attitudinal determinants of forest biotechnology preferences, respondents who are more trusting in industry and have more positive attitudes toward science are more likely to vote for a proposed forest policy over the current policy. This result implies that the above attitudes are linked to acceptance of allowing the planting of non-local trees on public land, whether bred via traditional breeding, or bred with the aid of genomic science or GM. Trust in other agencies, such as the federal or provincial governments did not have a statistically significant effect on forest policy voting behaviour, and were therefore excluded from the final No ME and ICLV models. Environmental concern, as measured by items from the NEP scale (Dunlap et al. 2000), as well as the entire NEP scale, had no statistically significant impact on forest policy preference. This may be explained by the fact that each proposed policy involves an environmental risk (introduction of non-local trees on public land), but also environmental benefits (biofuel production or increase in non-harvested forest). While knowledge is often a significant determinant of biotechnology preference, the biotechnology and forestry knowledge scales were not suitable for inclusion in the ICLV model, so no inferences could be made with respect to knowledge. Attitudinal results may be specific to Alberta, and may not necessarily apply to the general public of Canada as a whole, so future research on other Canadian samples is recommended.

3.5: Literature Cited

Alberta Environment and Sustainable Resource Development. (2009). Alberta Forest Genetic Resource Management and Conservation Standards. Report No. 978-0-7785-8467-4.

Alberta Environment and Sustainable Resource Development (2013). Forest management agreements: FMA holders. Retrieved November 2, 2013 from http://esrd.alberta.ca/lands-forests/forest-management/forest-management-agreements/fma-holders.aspx.

Anderson, J. A., Armstrong, G. W., Luckert, M. K., & Adamowicz, W. L. (2012). Optimal zoning of forested land considering the contribution of exotic plantations. *Mathematical and Computational Forestry & Natural-Resource Sciences*, *4*, 92-104.

Ashok, K., Dillon, W. R., & Yuan, S. (2002). Extending discrete choice models to incorporate attitudinal and other latent variables. *Journal of Marketing Research*, *39*, 31-46.

Bak, H.-J. (2001). Education and Public Attitudes toward Science: Implications for the “Deficit Model” of Education and Support for Science and Technology. *Social Science Quarterly*, *82*, 779–795.

Bauer, M. W., Petkova, K., & Boyadjieva, P. (2000). Public knowledge of and attitudes to science: Alternative measures that may end the “science war”. *Science, Technology & Human Values*, *25*, 30-51.

Bem, D. J. (1972). Self-perception theory. *Advances in Experimental Social Psychology*, *6*, 1-62.

Blumenschein, K., Johannesson, M., Blomquist, G. C., Liljas, B., O’Connor, R. M. (1998). Experimental results on expressed certainty and hypothetical bias in contingent valuation *Southern Economic Journal 65,*169–77.

Boxall, P. C., Adamowicz, W. L., Olar, M., West, G. E., & Cantin, G. (2012). Analysis of the economic benefits associated with the recovery of threatened marine mammal species in the Canadian St. Lawrence Estuary. *Marine Policy*, *36*(1), 189-197.

Bredahl, L. (2001). Determinants of consumer attitudes and purchase intentions with regard to genetically modified food–results of a cross-national survey. *Journal of Consumer Policy*, *24*, 23-61.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. New York, NY: Guilford Press.

Carifio, J., & Perla, R. J. (2007). Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antidotes. *Journal of Social Sciences*, *3*, 106.

Carson, R. T., & Groves, T. (2007). Incentive and informational properties of preference questions. *Environmental & Resource Economics*, *37*, 181-210.

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy*, *33*, 99-111.

Costa-Font, M., & Gil, J. M. (2009). Structural equation modelling of consumer acceptance of genetically modified (GM) food in the Mediterranean Europe: A cross country study. *Food Quality and Preference*, *20*, 399-409.

Costa-Font, M., & Gil, J. M. (2012). Meta-attitudes and the local formation of consumer judgments towards genetically modified food. *British Food Journal*, *114*, 1463-1485.

DeVellis, R. F. (2003). *Scale Development: Theory and Applications, 2nd Ed.* Thousand Oaks, CA: Sage Publications, Inc.

DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*, 1-11.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of Social Issues*, *56*, 425-442.

Earle, T. C., & Cvetkovich, G. (1995). *Social trust: Toward a Cosmopolitan Society*. Westport, CT: Praeger Publishers.

Eiser, J. R., Miles, S., & Frewer, L. J. (2002). Trust, perceived risk, and attitudes toward food technologies. *Journal of Applied Social Psychology, 32*, 2423-2433.

Festinger, L. (1962). Cognitive Dissonance. *Scientific American, 207,* 93-107.

Gaskell, G., Allum, N., & Stares, S. (2003). Europeans and biotechnology in 2002: Eurobarometer 58.0. Brussels: European Commission.

Genome British Columbia. (2014). *Research Projects: POPCAN*. Retrieved October 28, 2014 from http://www.genomebc.ca/research-programs/projects/energy-mining-environment/popcan.

Genome Canada. (2014). *Research Portfolio: Forestry.* Retrieved December 12, 2014 from http://www.genomecanada.ca/en/portfolio/project/forestry.aspx.

Gibson, F.L. and Burton, M.P. (2011) *Determining the Change in Welfare Estimates from Introducing Measurement Error in Non-Linear Choice Models*, Working Paper 1110, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

Gibson, F. L., & Burton, M. (2014). Salt or Sludge? Exploring preferences for potable water sources. *Environmental & Resource Economics*, *57*, 453-476.

Greene, W. H. (2008). *Econometric Analysis, 6th Ed.* Upper Saddle River, N.J.: Pearson Education Inc.

Hajjar, R., McGuigan, E., Moshofsky, M., & Kozak, R. (2014). Opinions on strategies for forest adaptation to future climate conditions in Western Canada: Surveys of the general public and leaders of forest-dependent communities. *Canadian Journal of Forest Research*, *44,* 1525-1533.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate Data Analysis, 6th ed.* Upper Saddle River, N.J.: Pearson Education Inc.

Hess, S., & Beharry-Borg, N. (2012). Accounting for latent attitudes in willingness-to-pay studies: the case of coastal water quality improvements in Tobago. *Environmental & Resource Economics 52*, 109-131.

House, L., Lusk, J., Jaeger, S., Traill, W. B., Moore, M., Valli, C., Morrow, B. & Yee, W. M. (2005). Objective and subjective knowledge: impacts on consumer demand for genetically modified foods in the United States and the European Union. *AgBioForum 7,* 113-123.

Huber, P. J. (1967). The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability* (Vol. 1, No. 1, 221-233).

Jamieson, S. (2004). Likert scales: how to (ab) use them. *Medical education*, *38*, 1217-1218.

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research*, *30*, 199-218.

Jöreskog, K. G., & Goldberger, A. S. (1975). Estimation of a model with multiple indicators and multiple causes of a single latent variable. *Journal of the American Statistical Association*, *70*, 631-639.

Kline, R. B. (2011), *Principles and practice of structural equation modeling, 3rd ed*. New York, NY: Guilford Press.

Lang, J. T., & Hallman, W. K. (2005). Who does the public trust? The case of genetically modified food in the United States. *Risk Analysis*, *25*, 1241-1252.

Lusk, J. L. (2011). Chapter 10: Consumer preferences for genetically modified food. In C. A. Carter, G. Moschini, & I. Sheldon (Eds.), *Genetically Modified Food and Global Welfare (Frontiers of Economics and Globalization, Vol. 10)* (pp. 243-262). Bingley, UK: Emerald Group Publishing Ltd.

Lusk, J. L., & Coble, K. H. (2005). Risk perceptions, risk preference, and acceptance of risky food. *American Journal of Agricultural Economics*, *87*, 393-405.

Marciano, J. A., Lilieholm, R. J., Teisl, M. F., Leahy, J. E., & Neupane, B. (2014). Factors affecting public support for forest-based biorefineries: A comparison of mill towns and the general public in Maine, USA. *Energy Policy*, *75*, 301-311.

Matin, A. H., Goddard, E., Vandermoere, F., Blanchemanche, S., Bieberstein, A., Marette, S., & Roosen, J. (2012). Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology?. *International Journal of Consumer Studies*, *36*, 149-157.

McFarlane, B. L., & Boxall, P. C. (2000). Factors influencing forest values and attitudes of two stakeholder groups: The case of the Foothills Model Forest, Alberta, Canada. *Society & Natural Resources*, *13*, 649-661.

McFarlane, B. L. (2005). Public perceptions of risk to forest biodiversity. *Risk Analysis, 25,* 543-553.

McKelvey, R. D., & Zavoina, W. (1975). A statistical model for the analysis of ordinal level dependent variables. *Journal of Mathematical Sociology*, *4*, 103-120.

Minister of Justice. (2013). Renewable fuels regulations. SOR/2010-189. Accessed October 28, 2014 from http://laws-lois.justice.gc.ca/PDF/SOR-2010-189.pdf.

Morikawa, T., Ben-Akiva, M., & McFadden, D. (2002). Discrete choice models incorporating revealed preferences and psychometric data. *Advances in Econometrics*, *16*, 29-56.

Murphy, J. J., Allen, P. G., Stevens, T. H., & Weatherhead, D. (2005). A meta-analysis of hypothetical bias in stated preference valuation. *Environmental & Resource Economics*, *30*, 313-325.

Muthén, L. K., & Muthén, B. O. (2010). *Mplus user's guide.* Muthén & Muthén: Los Angeles, CA.

Natural Resources Canada. (2009). The state of Canada's forests: annual report 2009. Cat. No. Fo1-6/2009PDF.

Natural Resources Canada. (2012). The state of Canada's forests: annual report 2012. Cat. No. Fo1-6/2012E-PDF.

Paternoster, R., Brame, R., Mazerolle, P., & Piquero, A. (1998). Using the correct statistical test for the equality of regression coefficients. *Criminology*, *36*, 859-866.

Pin, R. R., & Gutteling, J. M. (2009). The development of public perception research in the genomics field: An empirical analysis of the literature in the field. *Science Communication*, *31,* 57-83.

Poortinga, W., & Pidgeon, N. F. (2005). Trust in risk regulation: Cause or consequence of the acceptability of GM food? *Risk Analysis, 25*, 197-207.

Poortinga, W., & Pidgeon, N. F. (2006). Prior Attitudes, Salient Value Similarity, and Dimensionality: Toward an Integrative Model of Trust in Risk Regulation. *Journal of Applied Social Psychology*, *36*, 1674-1700.

Roosen, J., Bieberstein, A., Blanchemanche, S., Goddard, E., Marette, S., & Vandermoere, F. (2015). Trust and willingness to pay for nanotechnology food. *Food Policy* (DOI: 10.1016/j.foodpol.2014.12.004).

Schmer, M. R., Vogel, K. P., Mitchell, R. P., & Perrin, R. K. (2008). Net energy of cellulosic ethanol from switchgrass. *Proceedings of the National Academy of Sciences, 105*, 464-469.

Schwarz, G. E. (1978). Estimating the dimension of a model. *Annals of Statistics, 6,* 461–464.

Siegrist, M. (2010). Predicting the future: review of public perception studies of nanotechnology. *Human and Ecological Risk Assessment*, *16*, 837-846.

Skrondal, A., & Rabe-Hasketh, S. (2004). *Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*. Boca Raton, FL: Chapman & Hall/CRC.

Slimak, M. W., & Dietz, T. (2006). Personal values, beliefs, and ecological risk perception. *Risk Analysis*, *26*, 1689-1705.

Statistics Canada (2012a). Population and dwelling counts, for Canada, provinces and territories, census metropolitan areas and census agglomerations, 2011 and 2006 censuses (table). Population and Dwelling Count Highlight Tables. 2011 Census. Statistics Canada Catalogue no. 98-310-XWE2011002.

Statistics Canada (2012b). 2011 National Household Survey. Statistics Canada Catalogue no. 99-012-X2011040.

Statistics Canada. (2013). Statistics Canada. Table 358-0167 - Canadian Internet use survey, household access to the Internet at home, by household income quartile, Canada and provinces. CANSIM (database). (Retrieved August 5, 2014).

Steel, B. S., List, P., & Shindler, B. (1994). Conflicting values about federal forests: a comparison of national and Oregon publics. *Society and Natural Resources*, *7*, 137–153.

Sturgis, P., Cooper, H., & Fife-Schaw, C. (2005). Attitudes to biotechnology: Estimating the opinions of a better-informed public. *New Genetics & Society, 24,* 31-56.

Temme, D., Paulssen, M., & Dannewald, T. (2008). Incorporating latent variables into discrete choice models—a simultaneous estimation approach using SEM software. *Business Research*, *1*, 220-237.

Train, K. E., McFadden, D. L., & Goett, A. A. (1987). Consumer attitudes and voluntary rate schedules for public utilities. *The Review of Economics and Statistics 69*, 383-391.

Walker, J. L. (2001). *Extended Discrete Choice Models: Integrated Framework, Flexible Error Structures, and Latent Variables* (Doctoral dissertation, Massachusetts Institute of Technology).

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica, 48*, 817-838.

Chapter 5: Conclusions

This thesis was presented as two papers examining two distinct research areas. In chapter 2, public preferences for different proposed forest policies allowing non-native poplars on public land in British Columbia, Alberta, Saskatchewan, and Manitoba were examined. These proposed policies were compared to the current policy in each province, elicited using a SPCE set up as a provincial referendum, in order to determine which policies are preferred and which segments of the public prefer them. In chapter 3, these SPCE responses were used to build an ICLV model, allowing for attitudes to be used as covariates in the choice model. The ICLV model was compared to a basic choice model involving no attitudinal variables, and a model specifying latent attitudes as observed variables (No ME model).

In chapter 2, support rates for proposed policies significantly varied between provinces, with British Columbians least likely to vote for a new policy, and Albertans most likely. This result may be explained by differences in respondent characteristics across provinces, or by the differences in forest industry and composition in each province, and therefore different SPCE attribute levels. Minimal differences in public acceptance levels were noticed between different poplar-breeding methods, though GM was least preferred. Overall, the level of acceptance of new poplar breeding methods is still somewhat ambiguous. Acceptance of many proposed policy scenarios was well above 50%, but substantially decreased when only respondents who were *very certain* of their responses were taken into account. Further, it seems that policy acceptance is highly dependent on associated outcomes of policy changes, yet the dynamics of these outcomes are not yet well understood. Specifically, respondents rated parent tree source as the most important driver of their preferences, but it is unknown how this policy attribute might impact potential outcomes of POPCAN research. Thus, to better understand public acceptance of the use of genomics in forestry, a better understanding of how applying genomics to forestry will affect the environment, industry, and society is necessary.

For future research in this realm, the dynamics of outcomes associated with genomics research and public preferences should be investigated. In this study, proposed policies varied by breeding method and biofuel production, but other associated outcomes were correlated with these policy variables. Thus, some uncertainty exists over why certain respondents preferred certain policies. To address this issue, further SPCE scenarios that allow policy attributes and outcomes to vary, rather than be strictly correlated with breeding method, could be developed and administered to the public. Further, it would be of interest to understand how certain outcomes excluded from the SPCE, such as tree-species diversity or some metric of environmental risk, might affect preferences.

In chapter 3, the two models incorporating attitudes as explanatory variables (ICLV and No ME) exhibited preferable fit statistics to the Basic model. When comparing marginal effect estimates between the ICLV and No ME models, no significant differences were found. However, by foregoing the step of regressing attitudinal variables on observed individual specific variables, the No ME model is only able to determine the direct effect of each covariate on the choice outcome, while the ICLV model allows for determining direct, indirect, and total effects. This difference between the models has two implications. First, the ICLV modeling approach allows for a more detailed explanation of individuals' preferences. Second, the No ME model is prone to Type I and II errors for parameter estimates linking observed individual-specific characteristics to the choice outcome. This issue occurs because the single-equation model estimates direct effects of individual-specific variables while controlling for attitudes, which complicates the task of identifying policy supporters. Thus, it is crucial that researchers understand how the interpretation of the effects of observed covariates on the choice outcome may change when attitudes are used as covariates in a single equation choice model.

Further research is recommended to better understand how results may differ between ICLV and No ME models in general. Though no significant difference in marginal effect estimates was found between the ICLV and No ME models, simulation studies are recommended to better understand this issue. For instance, it would be of interest to analyze changes in parameter bias as other aspects of the model change and interact, such as alpha coefficients of the psychometric scales, the number of response categories for Likert-type items, or different model specifications relating to the latent variables. Further, it would be of interest to examine potential parameter bias in a wider variety of contexts than in this study, as the results found may not necessarily be generalizable to all ICLV model applications and contexts.

Chapter 6: Literature Cited

Alberta Environment and Sustainable Resource Development. (2009). Alberta Forest Genetic Resource Management and Conservation Standards. Report No. 978-0-7785-8467-4.

Alberta Environment and Sustainable Resource Development (2013). Forest management agreements: FMA holders. Retrieved November 2, 2013 from http://esrd.alberta.ca/lands-forests/forest-management/forest-management-agreements/fma-holders.aspx.

Anderson, J. A., Armstrong, G. W., Luckert, M. K., & Adamowicz, W. L. (2012). Optimal zoning of forested land considering the contribution of exotic plantations. *Mathematical and Computational Forestry & Natural-Resource Sciences*, *4*, 92-104.

Ashok, K., Dillon, W. R., & Yuan, S. (2002). Extending discrete choice models to incorporate attitudinal and other latent variables. *Journal of Marketing Research*, *39*, 31-46.

Bak, H.-J. (2001). Education and Public Attitudes toward Science: Implications for the "Deficit Model" of Education and Support for Science and Technology. *Social Science Quarterly*, *82*, 779–795.

Bauer, M. W., Petkova, K., & Boyadjieva, P. (2000). Public knowledge of and attitudes to science: Alternative measures that may end the "science war". *Science, Technology & Human Values*, *25*, 30-51.

Bem, D. J. (1972). Self-perception theory. *Advances in experimental social psychology*, *6*, 1-62.

Blumenschein, K., Johannesson, M., Blomquist, G. C., Liljas, B., O'Connor, R. M. (1998). Experimental results on expressed certainty and hypothetical bias in contingent valuation *Southern Economic Journal 65,*169–77.

Boxall, P. C., Adamowicz, W. L., Olar, M., West, G. E., & Cantin, G. (2012). Analysis of the economic benefits associated with the recovery of threatened marine mammal species in the Canadian St. Lawrence Estuary. *Marine Policy*, *36*, 189-197.

Bredahl, L. (2001). Determinants of consumer attitudes and purchase intentions with regard to genetically modified food–results of a cross-national survey. *Journal of Consumer Policy*, *24*, 23-61.

British Columbia Ministry of Forest, Lands, and Natural Resource Operations (2014). Timber supply review: TSR and TSA schedule. Retrieved January 10, 2014 from http://www.for.gov.bc.ca/hts/aactsa.htm.

Brown, T. A. (2006). *Confirmatory Factor Analysis for Applied Research*. New York, NY: Guilford Press.

Carifio, J., & Perla, R. J. (2007). Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antidotes. *Journal of Social Sciences*, *3*, 106.

Carson, R. T., & Groves, T. (2007). Incentive and informational properties of preference questions. *Environmental & Resource Economics*, *37*, 181-210.

Costa-Font, M., & Gil, J. M. (2009). Structural equation modelling of consumer acceptance of genetically modified (GM) food in the Mediterranean Europe: A cross country study. *Food Quality and Preference*, *20*, 399-409.

Costa-Font, M., & Gil, J. M. (2012). Meta-attitudes and the local formation of consumer judgments towards genetically modified food. *British Food Journal*, *114*, 1463-1485.

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy*, *33*, 99-111.

DeVellis, R. F. (2003). *Scale development: theory and applications, 2nd Ed.* Thousand Oaks, CA: Sage Publications, Inc.

DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*, 1-11.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of Social Issues*, *56*, 425-442.

Earle, T. C., & Cvetkovich, G. (1995). *Social trust: Toward a cosmopolitan society*. Westport, CT: Praeger Publishers.

Eiser, J. R., Miles, S., & Frewer, L. J. (2002). Trust, perceived risk, and attitudes toward food technologies. *Journal of Applied Social Psychology, 32*, 2423-2433.

Festinger, L. (1962). Cognitive Dissonance. *Scientific American, 207,* 93-107.

Gaskell, G., Allum, N., & Stares, S. (2003). Europeans and biotechnology in 2002: Eurobarometer 58.0. Brussels: European Commission.

Genome British Columbia. (2014). *Research Projects: POPCAN*. Retrieved October 28, 2014 from http://www.genomebc.ca/research-programs/projects/energy-mining-environment/popcan.

Genome Canada. (2014). *Research Portfolio: Forestry.* Retrieved December 12, 2014 from http://www.genomecanada.ca/en/portfolio/project/forestry.aspx.

Genome Canada. (2015). *GE^3LS: Genomics & Society.* Retrieved March 26, 2015 from http://www.genomecanada.ca/en/ge3ls/.

Gibson, F.L. and Burton, M.P. (2011) *Determining the Change in Welfare Estimates from Introducing Measurement Error in Non-linear Choice Models*, Working Paper 1110, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

Gibson, F. L., & Burton, M. (2014). Salt or Sludge? Exploring preferences for potable water sources. *Environmental & Resource Economics*, *57*, 453-476.

Greene, W. H. (2008). *Econometric Analysis, 6^{th} Ed.* Upper Saddle River, N.J.: Pearson Education Inc.

Guigou Cairus, G. (2008). *Estimating Genetic Flow Between Exotic and Native Poplar Species in Quebec.* (Master's Thesis, University of Laval).

Hajjar, R., McGuigan, E., Moshofsky, M., & Kozak, R. (2014). Opinions on strategies for forest adaptation to future climate conditions in Western Canada: Surveys of the general public and leaders of forest-dependent communities. *Canadian Journal of Forest Research*, *44,* 1525-1533.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate Data Analysis, 6th ed.* Upper Saddle River, N.J.: Pearson Education Inc.

Harshaw, H.W. (2012). *Optimized Populous feedstocks and novel enzyme systems for a British Columbia bioenergy sector: Understanding the social context of strategies to develop* *biofuels from optimized Populus feedstocks – The British Columbia Bioenergy Survey*. Vancouver, BC: Department of Forest Resources Management, Faculty of Forestry, the University of British Columbia.

Hess, S., & Beharry-Borg, N. (2012). Accounting for latent attitudes in willingness-to-pay studies: the case of coastal water quality improvements in Tobago. *Environmental & Resource Economics 52*, 109-131.

House, L., Lusk, J., Jaeger, S., Traill, W. B., Moore, M., Valli, C., Morrow, B. & Yee, W. M. (2005). Objective and subjective knowledge: impacts on consumer demand for genetically modified foods in the United States and the European Union. *AgBioForum 7,* 113-123.

Huber, P. J. (1967). The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the fifth Berkeley symposium on mathematical statistics and probability* (Vol. 1, No. 1, 221-233).

Jamieson, S. (2004). Likert scales: how to (ab) use them. *Medical education*, *38*(12), 1217-1218.

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research*, *30*, 199-218.

Jöreskog, K. G., & Goldberger, A. S. (1975). Estimation of a model with multiple indicators and multiple causes of a single latent variable. *Journal of the American Statistical Association*, *70*, 631-639.

Kline, R. B. (2011), *Principles and Practice of Structural Equation Modeling, 3rd ed*. New York, NY: Guilford Press.

Lang, J. T., & Hallman, W. K. (2005). Who does the public trust? The case of genetically modified food in the United States. *Risk Analysis*, *25*, 1241-1252.

LP Canada Ltd. (2014). Swan Valley forest management plan: documents. Retrieved January 15, 2014 from http://www.swanvalleyforest.ca/documents.html.

Lusk, J. L. (2011). Chapter 10: Consumer preferences for genetically modified food. In C. A. Carter, G. Moschini, & I. Sheldon (Eds.), *Genetically Modified Food and Global Welfare*

(Frontiers of Economics and Globalization, Vol. 10) (pp. 243-262). Bingley, UK: Emerald Group Publishing Ltd.

Lusk, J. L., & Coble, K. H. (2005). Risk perceptions, risk preference, and acceptance of risky food. *American Journal of Agricultural Economics*, *87*, 393-405.

Marciano, J. A., Lilieholm, R. J., Teisl, M. F., Leahy, J. E., & Neupane, B. (2014). Factors affecting public support for forest-based biorefineries: A comparison of mill towns and the general public in Maine, USA. *Energy Policy*, *75*, 301-311.

Matin, A. H., Goddard, E., Vandermoere, F., Blanchemanche, S., Bieberstein, A., Marette, S., & Roosen, J. (2012). Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology?. *International Journal of Consumer Studies*, *36*, 149-157.

McFarlane, B. L. (2005). Public perceptions of risk to forest biodiversity. *Risk Analysis, 25,* 543-553.

McFarlane, B. L., & Boxall, P. C. (2000). Factors influencing forest values and attitudes of two stakeholder groups: The case of the Foothills Model Forest, Alberta, Canada. *Society & Natural Resources*, *13*, 649-661.

McKelvey, R. D., & Zavoina, W. (1975). A statistical model for the analysis of ordinal level dependent variables. *Journal of Mathematical Sociology*, *4*, 103-120.

Minister of Justice. (2013). Renewable fuels regulations. SOR/2010-189. Accessed October 28, 2014 from http://laws-lois.justice.gc.ca/PDF/SOR-2010-189.pdf.

Mistik Management Inc. (2013). Mistik forest management agreement area. Retrieved November 3, 2014 from http://www.mistik.ca/fma.htm.

Morikawa, T., Ben-Akiva, M., & McFadden, D. (2002). Discrete choice models incorporating revealed preferences and psychometric data. *Advances in Econometrics*, *16*, 29-56.

Murphy, J. J., Allen, P. G., Stevens, T. H., & Weatherhead, D. (2005). A meta-analysis of hypothetical bias in stated preference valuation. *Environmental & Resource Economics*, *30*, 313-325.

Muthén, L. K., & Muthén, B. O. (2010). *Mplus user's guide.* Muthén & Muthén: Los Angeles, CA.

Natural Resources Canada. (2009). The state of Canada's forests: annual report 2009. Cat. No. Fo1-6/2009PDF.

Natural Resources Canada. (2012). The state of Canada's forests: annual report 2012. Cat. No. Fo1-6/2012E-PDF.

Paternoster, R., Brame, R., Mazerolle, P., & Piquero, A. (1998). Using the correct statistical test for the equality of regression coefficients. *Criminology*, *36*, 859-866.

Pin, R. R., & Gutteling, J. M. (2009). The development of public perception research in the genomics field: An empirical analysis of the literature in the field. *Science Communication*, *31,* 57-83.

Poortinga, W., & Pidgeon, N. F. (2005). Trust in risk regulation: Cause or consequence of the acceptability of GM food? *Risk Analysis, 25*, 197-207.

Poortinga, W., & Pidgeon, N. F. (2006). Prior Attitudes, Salient Value Similarity, and Dimensionality: Toward an Integrative Model of Trust in Risk Regulation. *Journal of Applied Social Psychology*, *36*, 1674-1700.

Ready, R. C., Champ, P. A., & Lawton, J. L. (2010). Using respondent uncertainty to mitigate hypothetical bias in a stated choice experiment. *Land Economics 86,* 363-381.

Roosen, J., Bieberstein, A., Blanchemanche, S., Goddard, E., Marette, S., & Vandermoere, F. (2015). Trust and willingness to pay for nanotechnology food. *Food Policy* (DOI: 10.1016/j.foodpol.2014.12.004).

Schmer, M. R., Vogel, K. P., Mitchell, R. P., & Perrin, R. K. (2008). Net energy of cellulosic ethanol from switchgrass. *Proceedings of the National Academy of Sciences, 105*, 464-469.

Schwarz, G. E. (1978). Estimating the dimension of a model. *Annals of Statistics 6,* 461–464.

Siegrist, M. (2010). Predicting the future: review of public perception studies of nanotechnology. *Human and Ecological Risk Assessment*, *16*, 837-846.

Skrondal, A., & Rabe-Hasketh, S. (2004). *Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*. Boca Raton, FL: Chapman & Hall/CRC.

Slimak, M. W., & Dietz, T. (2006). Personal values, beliefs, and ecological risk perception. *Risk Analysis*, *26*, 1689-1705.

Statistics Canada (2012a). Population and dwelling counts, for Canada, provinces and territories, census metropolitan areas and census agglomerations, 2011 and 2006 censuses (table). Population and Dwelling Count Highlight Tables. 2011 Census. Statistics Canada Catalogue no. 98-310-XWE2011002.

Statistics Canada (2012b). 2011 National Household Survey. Statistics Canada Catalogue no. 99-012-X2011040.

Statistics Canada. (2013). Statistics Canada. Table 358-0167 - Canadian Internet use survey, household access to the Internet at home, by household income quartile, Canada and provinces. CANSIM (database). (Retrieved August 5, 2014).

Steel, B. S., List, P., & Shindler, B. (1994). Conflicting values about federal forests: a comparison of national and Oregon publics. *Society and Natural Resources*, *7*, 137–153.

Sturgis, P., Cooper, H., & Fife-Schaw, C. (2005). Attitudes to biotechnology: Estimating the opinions of a better-informed public. *New Genetics & Society, 24,* 31-56.

Susaeta, A., Alavalapati, J., Lal, P., Matta, J. R., & Mercer, E. (2010). Assessing public preferences for forest biomass based energy in the southern United States. *Environmental Management*, *45*, 697-710.

Temme, D., Paulssen, M., & Dannewald, T. (2008). Incorporating latent variables into discrete choice models—a simultaneous estimation approach using SEM software. *Business Research*, *1*, 220-237.

Tolko Industries Ltd. (2014). Annual harvest and renewal plan: operating plan. Retrieved January 17, 2015 from http://www.tolkomanitoba.com/AOP.htm.

Train, K. E., McFadden, D. L., & Goett, A. A. (1987). Consumer attitudes and voluntary rate schedules for public utilities. *The Review of Economics and Statistics 69*, 383-391.

Walker, J. L. (2001). *Extended Discrete Choice Models: Integrated Framework, Flexible Error Structures, and Latent Variables* (Doctoral dissertation, Massachusetts Institute of Technology).

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica, 48*, 817-838.

Appendix 1: Questionnaire

UNIVERSITY OF ALBERTA [redacted]

[redacted]

Public Perceptions of Forest Management Strategies

Investigators:

Peter Boxall
515 General Services Bldg
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-5694
pboxall@ualberta.ca

Curtis Rollins
515 General Services Bldg
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-1518
rollins1@ualberta.ca

Background: You are invited to participate in a study about managing our forests in western Canada. Results of this study will be used in support of a graduate student thesis and a report. The report may be viewed by researchers, policy makers, and industry members.

Purpose: To gauge public perceptions of policies in forest management and their impacts. This will allow us to understand the types of forest policies the public supports or opposes. This information may be used to inform forest policy and management.

Study Procedures: You will be asked to complete a survey. We will ask you about your views on several topics. You will be asked to make choices between different possible policy options. The survey should take approximately 30 minutes to complete.

Benefits: You will receive reward points from Ipsos in exchange for completing this survey. Results will help us understand public preferences for forest policies. This will allow forest stakeholders to make better-informed decisions.

Risks: There are no anticipated physical or psychological risks involved with this study.

Voluntary Participation: Participation in this study is voluntary. You may decline to answer any questions or participate in the study. You may decide to withdraw from this study at any time. Since no personal identifiers are attached to the data, you will not be able to withdraw from the study once we receive the data.

Confidentiality: No personal identifiers will be collected as part of the data. We will assign you a random ID number that will not be linked to any personal identifiers. All responses will be combined together. No individual responses will be identified in any reports. Data will be password protected, stored electronically on a secure server and deleted after 10 years. Data may only be viewed by the investigators or the Research Ethics Board. Data will be used to complete a graduate student thesis and a report. Policy makers, researchers, and industry members may view the report. Results may also be published in academic journals.

Further Information: If you have any questions about the study, please contact the investigator, Peter Boxall (pboxall@ualberta.ca or 780-492-5694). The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

Consent to Participate in this Research:
Completing and submitting this survey means that:

- ☐ This optional study has been explained to me. I have been given information to contact the researchers and ask questions,
- ☐ I have read this form,
- ☐ I am aware of the risks of participating in this optional study,
- ☐ I voluntarily consent to take part in this optional study.

[INTRO SCREEN]

Public Perceptions of Forest Management in Western Canada

Thank you for agreeing to take part in our survey.

We are seeking your opinions on forest management strategies in your province. All of the information you provide is strictly confidential. Your responses will be combined with those from other respondents, and only summaries of combined information will be used in reports and presentations. This survey should take approximately 30 minutes to complete.

If you have any questions or concerns about this survey, please contact us at:

Curtis Rollins	Dr. Peter Boxall
rollins1@ualberta.ca	pboxall@ualberta.ca
(780) 492-1518	(780) 492-5694

Department of Resource Economics and Environmental Sociology
515 General Services Building
University of Alberta
Edmonton AB T6G 2H1

[QUESTIONNAIRE]
We would like to begin by seeking your views on some issues relating to science, technology and society.

1. The statements listed below are about science and research. Please rate each statement on a scale of **1 (strongly disagree) to 5 (strongly agree)**.

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Strongly disagree
Disagree
Neutral
Agree
Strongly agree
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]

1. Scientific knowledge builds up continuously.
2. Science is policy neutral.
3. Science cannot be blamed for its misapplication.
4. Science is rational and unbiased.
5. All science is good science.
6. Scientific inquiry can know no limits.
7. Some day, science will present the true picture of the world.

2. The statements listed below are about the relationship between humans and the environment. Please rate each statement on a scale of **1 (strongly disagree) to 5 (strongly agree).**

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Strongly disagree
Disagree
Neutral
Agree
Strongly agree
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
We are approaching the limits of the number of people the earth can support.
Humans have the right to modify the environment to suit their needs.
When humans interfere with nature it often produces disastrous consequences.
Human ingenuity will ensure that we will NOT make the earth unlivable.
Humans are severely abusing the environment.
The earth has plenty of natural resources if we just learn how to develop them.
Plants and animals have as much right as humans to exist.
The balance of nature is strong enough to cope with the impacts of modern industrial nations.
Despite our special abilities humans are still subject to the laws of nature.
The so-called “environmental crisis” facing humankind has been greatly exaggerated.
The earth is like a spaceship with very limited room and resources.
Humans were meant to rule over the rest of nature.
The balance of nature is very delicate and easily upset.
Humans will eventually learn enough about how nature works to be able to control it.
If things continue on their present course, we will soon experience a major environmental catastrophe.

Many different groups are involved in forest management in Canada. We would now like to get your opinions about different Canadian organizations and their roles regarding forest management in your province.

3a.Please indicate your agreement or disagreement that each of the groups listed below have the **expertise to make a competent judgment** about **managing our forests**.

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Strongly disagree
Disagree
Neutral
Agree
Strongly agree
Don't know
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
Federal Government
Your Provincial Government
Scientists
Forest Industry
Environmental Non-Government Organizations

3b. Please indicate your agreement or disagreement that each of the groups listed below are **a useful source of information** about **managing our forests**.

3c. Please indicate your agreement or disagreement that each of the groups listed below **will do what is right for society** regarding **managing our forests**.

3d. Please indicate your agreement or disagreement that each of the groups listed below **will tell you the truth** about **managing our forests.**

4. The following statements relate to forestry. Please rate each statement on a scale of **1 (strongly disagree) to 5 (strongly agree).**

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Strongly disagree
Disagree
Neutral
Agree
Strongly agree
Don't know
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
1. Forest companies are required to follow government guidelines when harvesting wood.
2. There are no old-growth forests remaining in my province.
3. Most of my province's forested land is owned by the provincial government.
4. Forest fires help the lodgepole pine open its cones and release its seeds.
5. Clear-cutting is the most common method of harvesting trees in my province.
6. All areas where trees are harvested must be replanted in order for the forest to return.

5. The following statements are about biotechnology and genetics. Please rate each statement on a scale of **1 (strongly disagree) to 5 (strongly agree).**

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Strongly disagree
Disagree
Neutral
Agree
Strongly agree
Don't know
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
1. The yeast used to make beer contains living organisms.
2. The mother's genes determine whether the child is a girl.
3. The cloning of living things produces genetically identical copies.
4. By eating a genetically modified fruit, a person's genes could also become modified.
5. Tomatoes genetically modified with genes from catfish would probably taste "fishy."
6. Ordinary tomatoes do not contain genes, while genetically modified tomatoes do.
7. Genetically modified animals are always larger than ordinary animals.
8. More than half the human genes are identical to those of chimpanzees.
9. It is impossible to transfer animal genes into plants.
10. Genetically modified foods are created using radiation to create genetic mutations.
11. Seedless bananas are the result of many generations of selective breeding.

In the next few pages, you will be presented with information about forest management and policies. Please read this information carefully and reflect on how you feel different forest management styles will impact society. This information will help you answer questions later in the survey.

[NEW SCREEN]

Current Forestry Practices and Policies in Your Province

In your province, forest companies harvest trees from public land controlled by the provincial government. The government approves how much wood can be harvested each year. After harvest, companies must reforest the land with trees bred from parents from the same region. This is done for two main reasons:

- To create a future forest that is similar to the one that was previously there, and
- Because the parent trees from this region are thought to have a higher chance of survival.

6. Before today, how informed were you about forest management in your province?

Please select one response only

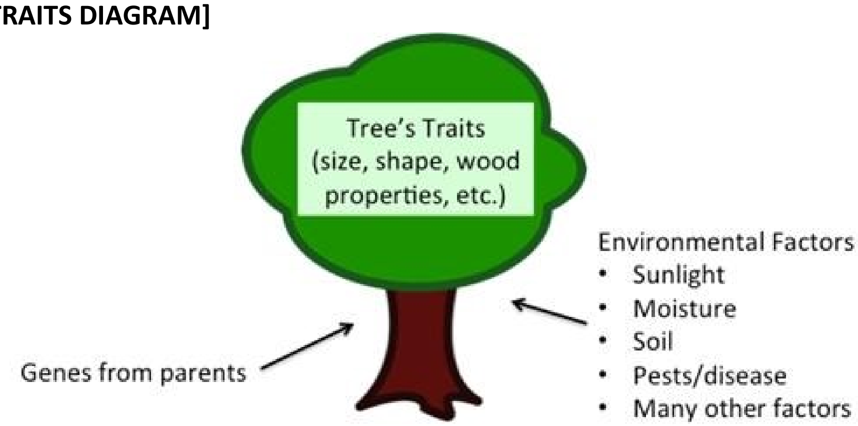
Not at all informed
Somewhat uninformed
Somewhat informed
Very informed

[NEW SCREEN]

Tree Traits, Genetics, and the Environment

A tree's characteristics or traits (*i.e.* its size, shape, wood properties, etc.) are determined by its genes and environment. Genes are a part of all trees (and all other living things), and pass traits from a parent to its offspring. A tree's genes are made of its DNA. The environment, such as sunlight and rain, will also help determine how a tree grows, thereby affecting its traits. For example, a tree may grow faster than others because of its genes, because it has a better environment, or because of both.

[INSERT TREE TRAITS DIAGRAM]



[NEW SCREEN]

Poplar Trees

Some species of poplar trees naturally occur in your province's forests. Poplars are fast growing, broad-leaf trees. When harvested, these trees can be used to make OSB (oriented strand board, which is similar to plywood and is widely used in the construction industry), paper products, or biofuels that cars and trucks can use.

Poplar trees can be planted or grown in 3 ways:

- By seed,
- By growing out of the ground from the roots of an existing tree,
- By planting a cutting of an existing tree.

7. Before today how familiar were you with information about poplar trees?

Please select one response only

[ACROSS TOP OF GRID]
[ROW 1]
Very Unfamiliar
Unfamiliar
Neutral
Familiar
Very Familiar
[ROW 2]
1
2
3
4
5

Poplars and Biofuels

Biofuels are an alternative to fossil fuels (e.g., oil, gas, and coal) that produce less net greenhouse gases. Biofuels are produced from biological sources, such as plants. In Canada, gasoline can contain up to l0% biofuel. Canadian biofuel is currently produced from agricultural crops, such as corn or wheat. Poplars could be used as an alternative source to produce these fuels.

Biofuels produce less net greenhouse gases because carbon is taken in by trees or plants while they grow. This offsets the carbon released when the fuel is burned.

8. Biofuels can be processed from several different sources. Some of these are listed below. Thinking of which potential source of biofuel is most acceptable to you, please rate the list below from **1 (very unacceptable)** to **5 (very acceptable)**.

Please select one response for each item

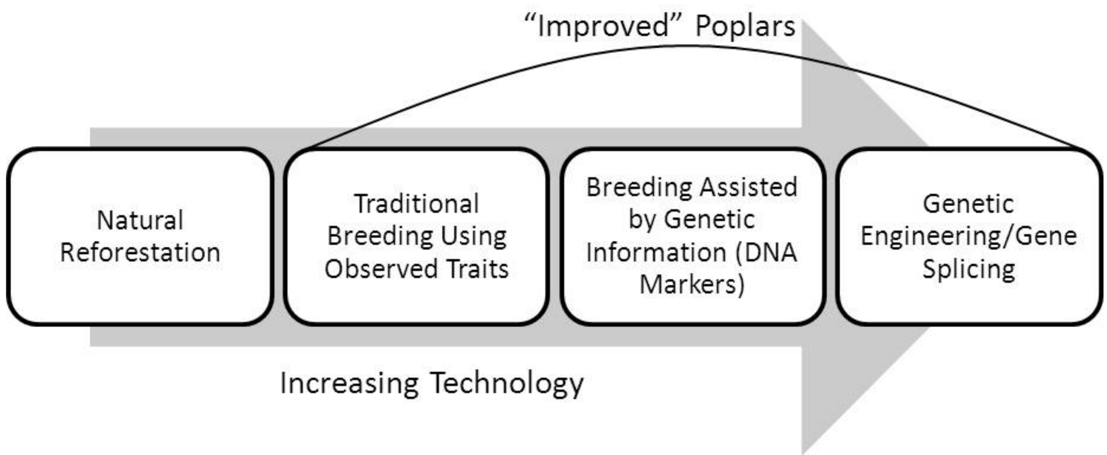
[ACROSS TOP OF GRID]
[ROW 1]
Very Unacceptable
Unacceptable
Neutral
Acceptable
Very Acceptable
Don't Know
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
Trees
Municipal Waste
Saw/Pulp Mill Residues
Agricultural Crops
Agricultural Waste (e.g. straw)

[IF QUOTA GROUP IS AB, AB T1, BC, SK OR MB INSERT: Approaches and Technology for Poplar Reforestation]
[IF QUOTA GROUP IS AB T2 INSERT: Approaches for Poplar Reforestation]

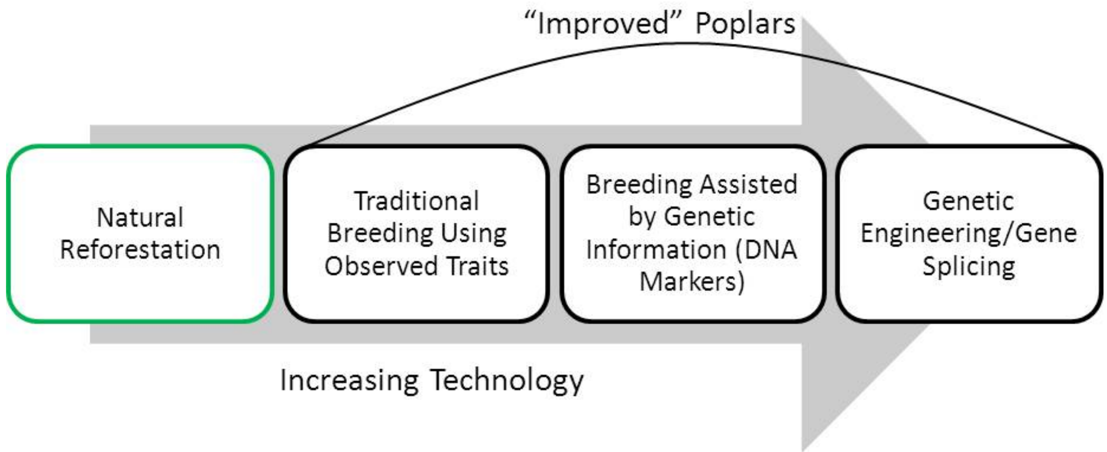
There are two approaches to reforesting poplars after harvest – planting new trees or cuttings, or letting trees grow from roots and seeds of the harvested trees. For trees that are planted, scientists are looking at new ways of breeding poplar trees with more desirable traits, such as faster growth. Trees that are bred to have more desirable traits will be referred to as "improved" poplars. The following pages will outline different ways poplar trees can be bred and reforestation can occur.

[IF QUOTA GROUP IS AB, BC, SK OR MB, INSERT ARROW DIAGRAM MAIN. IF QUOTA GROUP IS AB T1, INSERT ARROW DIAGRAM T1. IF QUOTA GROUP IS AB T2, INSERT ARROW DIAGRAM T2.]



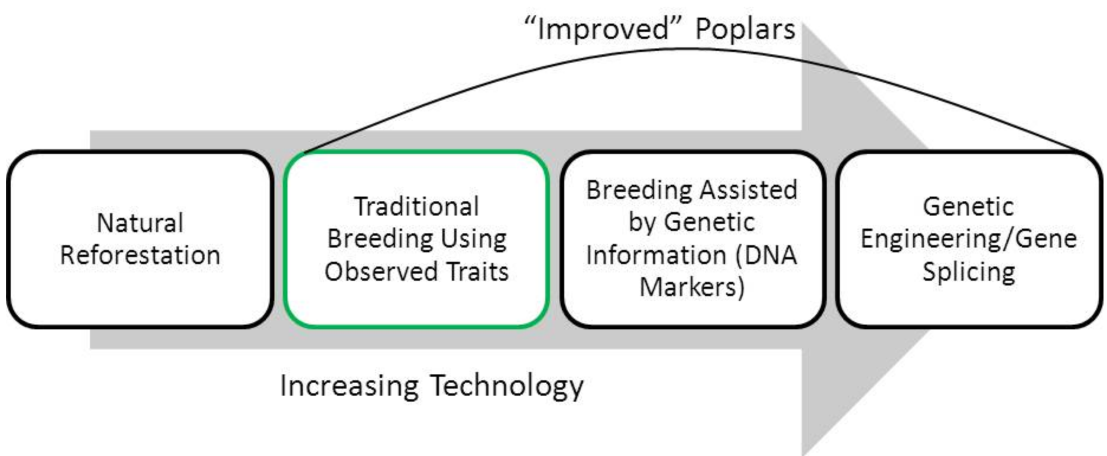
[NEW SCREEN]
Natural Reforestation – After poplar trees are harvested, trees continue to grow naturally from roots and seeds in the ground. The land is reforested from the roots and seeds of trees that were harvested, and nothing is replanted. This method is the most common way poplar stands are reforested in your province.

[IF QUOTA GROUP IS AB, BC, SK OR MB, INSERT ARROW DIAGRAM MAIN NAT REF GREEN. IF QUOTA GROUP IS AB T1, INSERT ARROW DIAGRAM T1 NAT REF GREEN. IF QUOTA GROUP IS AB T2, INSERT ARROW DIAGRAM T2 NAT REF GREEN.]



[NEW SCREEN]
Traditional breeding using observed traits – Parent trees are chosen for breeding because they have desirable traits. Trees with preferred traits are used in hopes that the offspring will also have these traits. Tree breeders must wait for the tree to mature to see these traits. These preferred trees can then be planted in the harvested forests. This method is currently allowed on public land in your province, but is only used on a small amount of land.

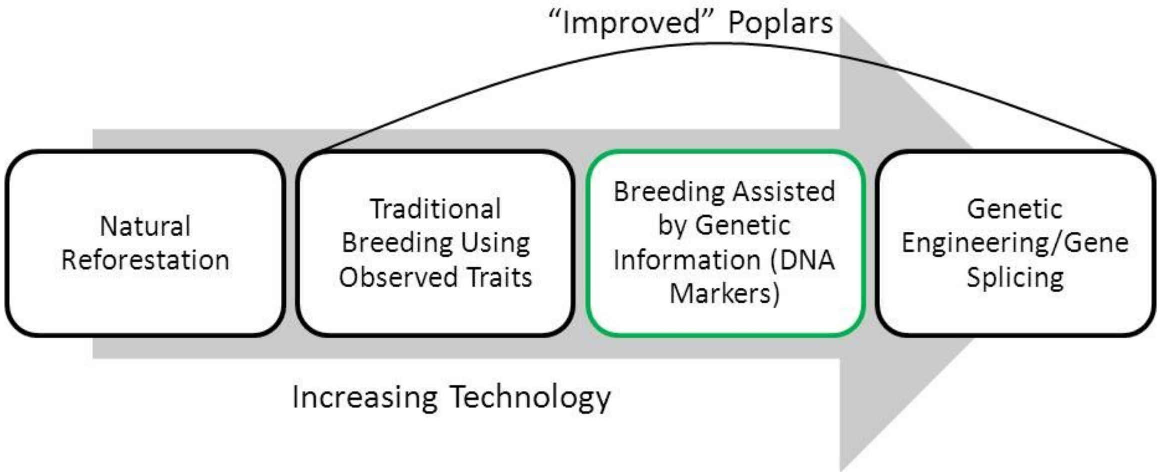
[IF QUOTA GROUP IS AB, BC, SK OR MB, INSERT ARROW DIAGRAM MAIN TRAD BREED GREEN. IF QUOTA GROUP IS AB T1, INSERT ARROW DIAGRAM T1 TRAD BREED GREEN. IF QUOTA GROUP IS AB T2, INSERT ARROW DIAGRAM T2 TRAD BREED GREEN.]



[NEW SCREEN] [DO NOT DISPLAY SCREEN IF QUOTA GROUP IS AB T2. SKIP TO Q9]
Breeding assisted by genetic information (DNA markers) –

Scientists have linked certain parts of a tree's DNA with preferred traits. Scientists can use this knowledge to choose parent trees for breeding. That is, scientists can look at the DNA of trees when selecting them for breeding. The trees are bred the same way as traditional breeding, but are selected based on their genetic information. This allows us to choose trees for breeding sooner, before a tree's traits are obvious (*i.e.* we don't need to wait for the tree to grow up before choosing it for breeding). Scientists can then breed several generations of trees in the same time it takes to breed one generation of trees using traditional breeding methods. This faster breeding process occurs in a lab or nursery for several generations. Then, the resulting trees would be planted for reforestation. Overall, this method allows us to gain the benefits of traditional selective breeding in less time. This method is widely used in agriculture for crops and animals, but is not used for forestry on public land. Before being planted on public land, these trees would have to be approved by your provincial government. However, these trees may be planted on private land without prior approval.

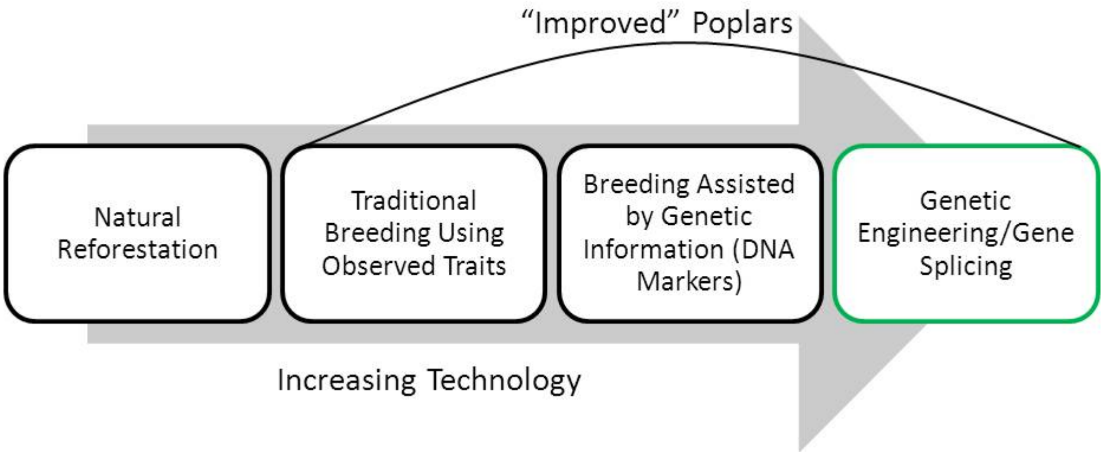
[IF QUOTA GROUP IS AB, BC, SK OR MB, INSERT ARROW DIAGRAM MAIN DNA MARK GREEN. IF QUOTA GROUP IS AB – T1, INSERT ARROW DIAGRAM T1 DNA MARK GREEN.



[NEW SCREEN] [DO NOT DISPLAY SCREEN IF QUOTA GROUP IS AB T1 OR AB T2. SKIP TO Q9.]
Genetic engineering/gene splicing – DNA linked to desirable traits is inserted into the genes of a tree by scientists in a laboratory. DNA from other plants and animals could be used. This allows for the highest degree of control over the genes a tree has, and thereby its traits. This method is often used for agricultural crops, such as canola or corn. It is possible for these trees to be made sterile (unable to breed with other trees). These trees could still spread from their roots, but probably not by seed. This can reduce the risk of these trees spreading to other areas or breeding with natural poplars. These trees currently cannot be planted on public land, and need to be approved by your provincial and federal

governments before planting. The federal government must also grant approval before these trees are planted on private land.

[IF QUOTA GROUP IS AB, BC, SK OR MB, INSERT ARROW DIAGRAM MAIN GEN ENG GREEN]



[NEW SCREEN]
9. How well do you feel you understand each of the terms?

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Do not understand at all
Understand very little
Neutral
Understand somewhat
Understand completely
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. DO NOT RANDOMIZE ORDER.]
Natural Reforestation
Traditional breeding using observed traits
Breeding assisted by genetic information (DNA markers) **[DO NOT DISPLAY IF AB T2]**
Genetic Engineering/Gene Splicing **[DO NOT DISPLAY IF AB T1 OR AB T2]**

[NEW SCREEN]
Selecting Parent Trees
Choosing trees from other regions for breeding expands the gene pool we are choosing from. This gives us more options when selecting parent trees. Having more options when choosing trees to breed increases our ability to breed trees with more desirable traits. However, planting non-local trees could be risky, as we are not completely certain of how they may affect their environment.

[NEW SCREEN]

Poplar Trees on Private vs. Public Land

Currently, there are few restrictions on what kinds of trees may be planted on privately owned land. As new breeding methods become available, some trees that cannot be planted on public land could be planted on private land, such as farms. These trees may be grown as plantations on farmland, similar to crops.

10. Now we would like to get your views on how acceptable you think different types of trees are for growing on **privately owned land**. Please rate each of the following on a scale from **1 (very unacceptable) to 5 (very acceptable).**

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Very Unacceptable
Somewhat Unacceptable
Neutral
Somewhat Acceptable
Very Acceptable
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
Planting trees using traditional breeding based on observed traits.
Planting trees using breeding assisted by genetic information (DNA markers). **[DO NOT DISPLAY IF AB T2]**
Planting genetically engineered trees. **[DO NOT DISPLAY IF AB T1 OR AB T2]**
Planting local/native trees.
Using parent trees from anywhere in the world.
Poplar trees used to produce biofuels.

In **[INSERT PROVINCE]**, forest companies may use roughly **[INSERT – AB OR BC:** 2/3**; SK:** 1/3**; MB:** 1/8**]** of the publicly owned forest. This will be referred to as the commercial public forest.

Broad-leaf trees, such as poplars, make up roughly **[INSERT:**1/8 of British Columbia's; 1/3 of Alberta's; 1/3 of Saskatchewan's; 1/3 of Manitoba's**]** commercial public forest. The rest of the commercial public forest is made of coniferous trees (trees with cones and needles), such as spruce or pine trees. Within the broad-leaf forest, there are three ways land is used by industry:

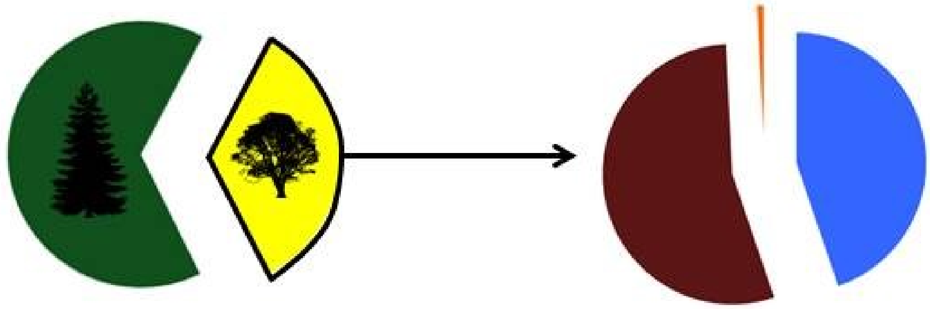
- Some land is not harvested;
- Some land is left to reforest through the roots of trees that were already harvested (natural reforestation) and will continue to be harvested; or
- Some land is planted to "improved" poplars and will be harvested.

Approximate estimates of **[INSERT PROVINCE]**'s commercial public forest land-use are shown below.

[INSERT 'LAND USE BREAKDOWN' IMAGE BASED ON QUOTA GROUP: AB / AB T1 / AB T2 / BC / SK / MB]

Current Situation

Alberta's Commercial Public Forest **Alberta's Broad-Leaf Commercial Public Forest**



Coniferous Forest (65%)
Broad-Leaf Forest (35%)

Harvested Natural Poplars (55%)
"Improved" Poplars (under 1%)
Non-Harvested Land (45%)

Possible New Situations and Policies

Below are estimates of how Alberta's broad-leaf commercial forests could be used under different policies:

Traditional Breeding, Parent Trees Come From Anywhere

Harvested Natural Poplars (28%)
"Improved" Poplars (10%)
Non-Harvested Land (62%)

Breeding Assisted by Genetic Information, Parent Trees Come From Anywhere

Harvested Natural Poplars (23%)
"Improved" Poplars (10%)
Non-Harvested Land (67%)

Genetic Engineering, Parent Trees Come From Anywhere

Harvested Natural Poplars (21%)
"Improved" Poplars (10%)
Non-Harvested Land (69%)

Impacts of Planting "Improved" Poplars on Public Land

[DO NOT INSERT TEXT IF QUOTA GROUP IS AB T2. IF QUOTA GROUP IS AB, AB T1, BC, SK OR MB INSERT: There are benefits and costs/risks associated with planting "improved" poplars on public land. In general, trees bred with higher levels of technology are linked to higher benefits. However, this could also be true for risks or potential costs. This is because "improved" poplars may differ more from natural poplars as more technology is used for breeding. Trees that differ more from natural trees will have a less predictable effect on their surrounding environment.**]**

[INSERT FOR ALL QUOTA GROUPS]

<u>Benefits of planting "improved" poplars on public land:</u>

- "Improved" poplars grow faster. We can use less land to produce the same amount of wood as we currently do.
- "Improved" poplars produce more valuable wood.
- "Improved" poplars can be used to produce biofuels. Natural poplars are less suitable for biofuel production. Biofuel use can reduce the net carbon emissions from vehicles. Producing biofuels from "improved" poplars also frees up farmland currently used for biofuel crops.

<u>Risks or possible costs of planting "improved" poplars on public land:</u>

- Land used for "improved" poplars may be negatively impacted.
    - Areas used for "improved" poplars will be harvested (disturbed) more frequently.
    - "Improved" poplars may require more soil nutrients and water because they grow faster than natural poplars.
- "Improved" poplars could spread to other areas or breed with natural poplars.
    - This could have unknown effects on other plant and animal life where "improved" poplars have spread.
- It is unknown how other plants and animals in "improved" poplar stands may be affected.

Now we are interested in how risky you believe each forest management strategy might be.
11a. Please state how risky you think each strategy is for society.

Please select one response for each item

[ACROSS TOP OF GRID]
Not at all risky
Not very risky
Somewhat risky
Very risky

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
Allowing reforestation from the roots of harvested trees (leave for natural).
Reforestation using traditional breeding based on observed traits.
Reforestation using breeding assisted by genetic information (DNA markers). **[DO NOT DISPLAY IF AB T2]**
Reforestation using genetically engineered trees (gene splicing). **[DO NOT DISPLAY IF AB T1 OR AB T2]**
Using parent trees only from the region where the new tree will be planted.
Using parent trees from anywhere in the world.
Using poplar trees to produce biofuels.

We are also interested in how beneficial you believe each forest management strategy might be.
11b. Please state how beneficial you think each strategy is for society.

Please select one response for each item

[ACROSS TOP OF GRID]
Not at all beneficial
Not very beneficial
Somewhat beneficial
Very beneficial

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
Allowing reforestation from the roots of harvested trees (leave for natural).
Reforestation using traditional breeding based on observed traits.
Reforestation using breeding assisted by genetic information (DNA markers). **[DO NOT DISPLAY IF AB T2]**
Reforestation using genetically engineered trees. **[DO NOT DISPLAY IF AB T1 OR AB T2]**
Using parent trees only from the region where the new tree will be planted.
Using parent trees from anywhere in the world.
Using poplar trees to produce biofuels.

The next series of questions will ask you to choose between current forest policy and management approaches and new possible approaches using “improved” poplars trees.

Currently, traditional breeding and natural reforestation are allowed on public land. We will provide estimates of some impacts of using new breeding methods connected with new policies. You will be asked to vote between **two options**: the current situation, and a new policy option. For each option, we will show you:

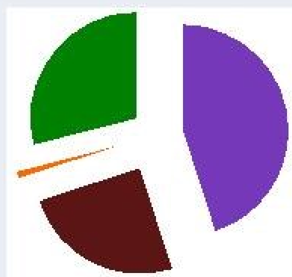
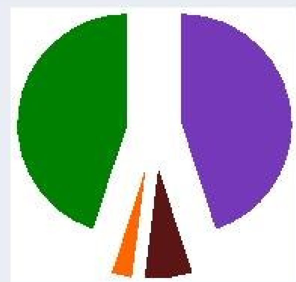
- How “improved” poplars are bred;
- Where the parent trees are from;
- How commercial forest land is or could be used;
- Impact on the forest industry; and
- The reduction in carbon emissions from using poplar biofuels.

Imagine you will be voting in a provincial referendum concerning changes to forest policy in your province. Please consider the information in each option below carefully. Then, decide if you would vote to keep the current policy or implement the new policy option presented.

First, **we will present one practice question.** The **practice question will not use real provincial data**, and **will not count as one of your votes**.

Practice Question: Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT PRACTICE QUESTION IMAGE]

Policy and Management Features	Current Policy and Management Approaches	New Policy and Management Approaches
"Improved" Poplars On Commercial Public Forest Land in your province		
Region where parent trees are located	Parent trees come from the same region as regenerated trees	Parent trees can come from any location
Breeding method	Traditional breeding using observed traits	Traditional breeding using observed traits
How <u>commercial public forest</u> land in your province is used	 Non-Harvested (29%) Harvested Coniferous Trees (45%) Harvested Natural Poplars (25%) Harvested "Improved" Poplars (1%)	 Non-Harvested (45%) Harvested Coniferous Trees (45%) Harvested Natural Poplars (7%) Harvested "Improved" Poplars (3%)
Impact on forest industry in your province (jobs and income)	No change	Large positive impact
Reduction in carbon emissions in your province from using biofuels from "improved" poplars	None	Equivalent to 150,000 cars off the road in your province

Practice A. Which scenario do you vote for? *Please click <u>here</u> to review definitions of related terms* **[DISPLAY DEFINITION IMAGE AS A POP-UP]**

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
Practice B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
Practice C. What percentage of residents in your province who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.* **[DISPLAY CHOICE CARD AS A POP-UP]**

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

[NEW SCREEN]

You will now vote [IF AB, BC, SK OR MB, INSERT: 6 times / IF AB T1, INSERT: 4 times / IF AB T2, INSERT 2 times]

- Choose ONLY ONE OPTION on each screen.
- Assume that the options on EACH SCREEN are the ONLY ones available.
- Each time, please vote **independently** from the other votes **–** Please do not compare the voting options on different screens. Just compare the two options being offered being offered.

PROGRAMMER INSTRUCTIONS

- ✓ **FOR AB, BC, SK OR MB, EACH RESPONDENT WILL BE SHOWN 6 CHOICE CARDS. FOR AB T1, EACH RESPONDENT WILL BE SHOWN 4 CHOICE CARDS. FOR AB T2, EACH RESPONDENT WILL BE SHOWN 2 CHOICE CARDS.**
- ✓ **CHOICE CARDS ARE DIFFERENT FOR EACH QUOTA GROUP**
- ✓ **RANDOMIZE ORDER OF PRESENTATION OF CHOICE CARDS**
- ✓ **ASSIGN THE FIRST CHOICE CARD SHOWN BASED ON LEAST FILL**
- ✓ **CREATE A VARIABLE THAT SPECIFIES WHICH CHOICE CARD IS SHOWN FOR VOTE 1, VOTE 2, VOTE 3, VOTE 4, vote 5 AND VOTE 6**

VOTE 1. Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT FIRST CHOICE CARD]

[DISPLAY QUESTION DIRECTLY BELOW CHOICE CARD]
VOTE1A. Which scenario do you vote for? *Please click here to review definitions of related terms*
[DISPLAY DEFINITION IMAGE AS A POP-UP]

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
VOTE1B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
VOTE1C. What percentage of **[INSERT PROVINCE]** residents who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.*
[DISPLAY CHOICE CARD AS A POP-UP]

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

VOTE 2. Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT FIRST CHOICE CARD]

[DISPLAY QUESTION DIRECTLY BELOW CHOICE CARD]
VOTE2A. Which scenario do you vote for? *Please click here to review definitions of related terms*
[DISPLAY DEFINITION IMAGE AS A POP-UP]

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
VOTE2B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
VOTE2C. What percentage of **[INSERT PROVINCE]** residents who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.*
[DISPLAY CHOICE CARD AS A POP-UP]

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

VOTE 3. Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT FIRST CHOICE CARD]

[DISPLAY QUESTION DIRECTLY BELOW CHOICE CARD]
VOTE3A. Which scenario do you vote for? *Please click here to review definitions of related terms*
[DISPLAY DEFINITION IMAGE AS A POP-UP]

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
VOTE3B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
VOTE3C. What percentage of **[INSERT PROVINCE]** residents who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.*
[DISPLAY CHOICE CARD AS A POP-UP]

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

VOTE 4. Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT FIRST CHOICE CARD]

[DISPLAY QUESTION DIRECTLY BELOW CHOICE CARD]
VOTE4A. Which scenario do you vote for? *Please click here to review definitions of related terms*
[DISPLAY DEFINITION IMAGE AS A POP-UP]

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
VOTE4B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
VOTE4C. What percentage of **[INSERT PROVINCE]** residents who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.*
[DISPLAY CHOICE CARD AS A POP-UP]

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

VOTE 5. Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT FIRST CHOICE CARD]

[DISPLAY QUESTION DIRECTLY BELOW CHOICE CARD]
VOTE5A. Which scenario do you vote for? *Please click here to review definitions of related terms*
[DISPLAY DEFINITION IMAGE AS A POP-UP]

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
VOTE5B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
VOTE5C. What percentage of **[INSERT PROVINCE]** residents who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.*
[DISPLAY CHOICE CARD AS A POP-UP]

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

VOTE 6. Consider the two scenarios below. Would you vote for the current situation or the new policy option if you were voting in a provincial referendum?

[INSERT FIRST CHOICE CARD]

[DISPLAY QUESTION DIRECTLY BELOW CHOICE CARD]
VOTE6A. Which scenario do you vote for? *Please click here to review definitions of related terms*
[DISPLAY DEFINITION IMAGE AS A POP-UP]

Please select one response only

Current Policy and Management Approaches
New Policy and Management Approaches

[NEW SCREEN]
VOTE6B. How certain are you that this is the choice you would make if this were a **real** provincial referendum?

Please select one response only

Very uncertain
Somewhat uncertain
Somewhat certain
Very certain

[NEW SCREEN]
VOTE6C. What percentage of **[INSERT PROVINCE]** residents who voted do you think would vote **in favor** of the **new policy** outlined above if this were a real referendum? *Please click here to review the policies.*
[DISPLAY CHOICE CARD AS A POP-UP]

Please provide your best estimate

[NUMERIC RESPONSE. RANGE 0 TO 100.] %

[ASK Q12A IF CURRENT POLICY SELECTED IN VOTE 1, 2, 3, 4, 5 OR 6]
12A. What were your reasons for voting to maintain the **current** policy and management strategy in any of the scenarios?

Please select all that apply

I do not believe the new policy would be carried out as outlined
I need more information before I can make a decision
I do not trust the government to run the proposed program effectively
I do not trust industry to run the proposed program effectively
I do not believe new breeding technologies are ethical
I do not agree with planting non-native trees on public land
The current policy is already doing a good job
New tree breeding technologies could damage the environment
New tree breeding technologies are too risky
New tree breeding technologies benefit industry, but society bears the risk
Other (Please specify)

[ASK Q12B IF NEW POLICY SELECTED IN VOTE 1, 2, 3, 4, 5 OR 6]
12B. What were your reasons for voting for the proposed **new** policy and management strategy in any of the scenarios?

Please select all that apply

I want to increase the amount of non-harvested forest area
I want to decrease carbon emissions
I want to increase biofuel production from poplars
I want to make the forest industry more profitable
This is necessary to grow enough wood for a growing population
The current policy seems out of date
Other (Please specify)

We would like to know more about your voting decisions in the forest management scenarios. Please let us know how important each factor was in deciding which policy you chose.

13. For each factor listed, please tell us how important it was in influencing your decisions of which policy to vote for (1 being "not at all important" and 5 being "very important").

Please select one response for each item

[ACROSS TOP OF GRID]
[ROW 1]
Not at all important
Not important
Neutral
Important
Very important
[ROW 2]
1
2
3
4
5

[DOWN SIDE OF GRID. RANDOMIZE ORDER.]
Amount of public forest land that is not harvested by the forest industry.
Impact on forest industry.
Region where parent trees are located.
Breeding method.
Reduction in carbon emissions in your province from making biofuels from "improved" poplars.

14. Do you think it is likely or unlikely that your choices on this survey will be used to help design forestry policy?

Please select one response only

Likely
Unlikely
Not sure

[NEW SCREEN] [DO NOT DISPLAY IF QUOTA GROUP IS AB T1 OR AB T2]
Debriefing

Please note that developing poplars via **genetic engineering (gene splicing)** is **not currently being researched** as part of this project. This concept was included to understand your preferences for using genetically engineered poplars in relation to other reforestation strategies. There is no plan to plant genetically engineered poplars in the foreseeable future in Canada.

[NEW SCREEN]
Now, imagine you are playing a lottery. A coin will be flipped to determine how much you win. There is an equal chance (50%) of the coin landing on "heads" or "tails". You are given six options to choose from with different payment amounts.

- For example, if you choose gamble 1, you would win $28 if the coin lands on "heads" or "tails" (either way, you will receive $28).
- If you choose gamble 6, you would win $2 if the coin lands on "heads", or $70 if the coin lands on "tails". You have an equal chance of winning $2 or $70 if you choose gamble 6.

15. Suppose you are given the following gambling options. Please choose your preferred gambling option.

	Roll	Payoff	Chances
Gamble 1	Heads	$28	50%
	Tails	$28	50%
Gamble 2	Heads	$24	50%
	Tails	$36	50%
Gamble 3	Heads	$20	50%
	Tails	$44	50%
Gamble 4	Heads	$16	50%
	Tails	$52	50%
Gamble 5	Heads	$12	50%
	Tails	$60	50%
Gamble 6	Heads	$2	50%
	Tails	$70	50%

Which gamble option do you choose?

Please select one response only

Gamble 1
Gamble 2
Gamble 3
Gamble 4
Gamble 5
Gamble 6

The final few questions are for statistical calculations. Please be assured all information will be kept completely confidential.

16. Do you consider yourself a rural resident?

Please select one response only

Yes
No

17. What is the population of the town or city in which you currently live?

Please select one response only

Live on a rural farm or acreage, outside of town
Less than 1,000 people
1,001-2,500 people
2,501-5,000 people
5,001-10,000 people
10,001-25,000 people
25,001-50,000 people
50,000-100,000 people
100,001-250,000 people
250,001-500,000 people
500,001-1,000,000 people
More than 1,000,000 people

18. Do you own or operate a farm in **[INSERT PROVINCE]**?

Please select one response only

Yes
No

19. Do you have any family members or close friends employed in the forest industry?

Please select one response only

I am employed in the forest industry
My spouse/partner is employed in the forest industry
An immediate family member is employed in the forest industry
An extended family member is employed in the forest industry
A close friend is employed in the forest industry
No

20. Are you a member of an environmental organization?

Please select one response only

Yes
No
Prefer not to say

21. What is the highest level of education you have completed?

Please select one response only

Grade school or some high school
High school diploma or equivalent
Post-secondary technical school
Some college or university
College degree or diploma
University undergraduate degree
University graduate degree (Masters or PhD)

Appendix 2: Focus Group Material

Focus Group (Round 1) Consent Form

UNIVERSITY OF ALBERTA [redacted]

[redacted]

Public'Perceptions'of'Forest'Management'Strategies'

Investigators:'

Peter Boxall
515 General Services Bldg
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-5694
pboxall@ualberta.ca

Sandeep Mohapatra
515 General Services Building
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-0823
smohapat@ualberta.ca

Marty Luckert
515 General Services Building
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-5002
mluckert@ualberta.ca

Curtis Rollins
515 General Services Bldg
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-1518
rollins1@ualberta.ca

Background: You are invited to participate in a study about managing our forests in western Canada. We are getting input from western Canadians over 18 years of age. Information collected in this session will help us design a survey to send to western Canadians. Survey results will be used in support of a graduate student thesis and a report. The report may be seen by policy makers, researchers, and industry.

Purpose: To gain an understanding of the public's perceptions of forest policies and management. Information collected from this session will be used to develop a survey on preferences for forest policies. Survey results may be used to inform forest policy and management.

Study'Procedures: During this focus group session, you will be presented with information about forest policies and management. This will be followed by a group discussion about perceptions of forest management strategies. The session will last no more than 90 minutes. There will be 10-14 participants in this focus group. All participants are over 18 years of age and live in western Canada. Notes will be taken based on the discussion. No personal identifiers will be attached to any data recorded.

Benefits: You will be given $50 for attending the focus group session. At the end of the session you will receive your earning in cash, where you must sign a receipt for it. The information you provide will give us insight on perceptions of forest management.

Risks: There are no anticipated physical or psychological risks involved with the focus group.**"!**

Voluntary'Participation: Participation in this study is voluntary. You may decline to answer any questions or participate in any part of the study. You may decide to withdraw from this study at any time without any penalty.

Confidentiality: No personal information will be collected as part of the data. Your name will only appear on the ethics consent form and your payment receipt. All other information recorded will be anonymous. Files will be stored in a locked filing cabinet in an investigator's office. These files will be destroyed after 5 years. Only the investigators and Research Ethics Board may access files and data. Data will be used to complete a graduate student thesis and a report. Policy makers, researchers, and industry members may view the report. Results may also be published in academic journals. If you would like a summary of the results when completed, contact Curtis Rollins (rollins1@ualberta.ca).

Further Information: If you have any questions about the study, please contact the investigator, Peter Boxall (pboxall@ualberta.ca or 780-492-5694). The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

Consent to Participate in this Research
My signature on this form means that:

- This optional study has been explained to me. I have been given the chance to discuss it and ask questions. All of my questions have been answered to my satisfaction,
- I have read each page of this form,
- I am aware of the risks of participating in this optional study,
- I voluntarily consent to take part in this optional study.

Name of Participant (Print)	Signature of Participant	Date
Name of Person Obtaining Consent (Print)	Signature of Person Obtaining Consent	Date

Focus Group (Round 1) Script

I. Introduction

- We appreciate you taking the time to come here and help us
- Introductions of the researchers
- Purpose of our meeting is for you to help us design a survey measuring preferences for new forest management policies. In particular, we will be focusing on preferences surrounding new tree breeding technologies for reforestation.
- First, I will give a short presentation outlining current forest policy in Alberta. Second, I will outline the new technologies being examined. Third, I will begin to present the implications of using different breeding technologies, which will lead into discussions of your perceptions of these technologies. Last, we will ask you to complete a small portion of the draft survey we have already been working on to evaluate its clarity.
- Before we begin, I ask that you read and sign a consent form if you agree to participate in this focus group. I remind you that participation is completely voluntary, and you may decide to stop participating at any time with no penalty.

II. Background Information (with powerpoint file)

- Outline of current forestry practices in Alberta – annual allowable cut, replanting requirements, and forest tenure on public land.

  - The province controls public forest lands.
- Outline of breeding technologies – parent tree source regulations and implications, breeding using genomic information, and genetic engineering.
- Outline of uses for plantation poplars: currently pulp and paper, future use: biofuel.

III. Discussion

- What types of benefits and risks/costs do you associate with:
  - Using trees from anywhere in the world?
  - Using trees from within the seed zone?
  - Using selective breeding by observed traits?
  - Using selective breeding with genetic technology?
  - Using genetic engineering
- If these trees can be used to increase preserved forest area, what sorts of benefits and risks do you associate with this management strategy?
- Planting Plantation Poplars on public vs. private land. What are the pros/cons of the two?
  - Land and food prices/scarcity?
  - Ethics of food supply, land-use change
- These trees may also be used to produce biofuels. Currently, gasoline for automobiles must contain at least 5% biofuel. Currently, most of Canada's bio-ethanol supply comes from wheat.
  - What are the pros/cons of using plantation poplars for biofuels?
  - Biofuels vs. pulp and paper?
  - Agricultural crops vs. trees?
  - Growing biofuels on public vs. private agricultural land?
  - Opinions of decreasing carbon emissions through biofuel use?

IV. Survey Pre-Test

- Now I will ask that you fill out a small portion of our survey. While this is just a draft and we could not incorporate all the information gathered tonight, we would like to get general impressions of clarity and readability. When answering the survey, feel free to leave comments in any places you think are confusing, biased, or should be improved in some way.

V. After Survey is Completed

- Examine the choice questions. See if anything is unclear, talk about ways to reduce bias.
- Is there any missing information? What key information do you think should be presented? Does the information provided "speak for itself", or should more linkages to impacts be provided?

VI. Thanks for coming, contact us if you would like further information.

Focus Group (Round 2) Consent Form

UNIVERSITY OF ALBERTA

RESOURCE ECONOMICS AND ENVIRONMENTAL SOCIOLOGY
FACULTY OF AGRICULTURAL, LIFE AND ENVIRONMENTAL SCIENCES

Peter Boxall
University Professor
515 General Services Building
Edmonton, Alberta, Canada T6G 2H1
Tel: 780.492.5694
pboxall@ualberta.ca
www.rees.ualberta.ca

!

<u>Public Perceptions of Forest Management Strategies</u>

Investigators:

Peter Boxall
515 General Services Bldg
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-5694
pboxall@ualberta.ca

Sandeep Mohapatra
515 General Services Building
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-0823
smohapat@ualberta.ca

Marty Luckert
515 General Services Building
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-5002
mluckert@ualberta.ca

Curtis Rollins
515 General Services Bldg
University of Alberta
Edmonton, AB T6G 2H1
Tel: (780) 492-1518
rollins1@ualberta.ca

Background:!You!are!invited!to!participate!in!a!study!about!managing!our!forests!in!western!Canada.! We!are!getting!input!from!western!Canadians!over!18!years!of!age.!Information!collected!in!this! session!will!help!us!design!a!survey!to!send!to!western!Canadians.!Survey!results!will!be!used!in! support!of!a!graduate!student!thesis!and!a!report.!The!report!may!be!seen!by!policy!makers,! researchers,!and!industry.!!

Purpose:!To!gain!an!understanding!of!the!public's!perception!of!forest!policies!and!management.! Information!collected!from!this!focus!group!will!be!used!to!develop!a!survey!measuring!preferences! for!different!forest!management!scenarios.!Survey!results!may!be!used!to!inform!forest!policy!and! management.!

Study Procedures:!During!this!focus!group!session,!you!will!be!presented!with!a!survey.!We!will!ask! you!to!complete!part!of!the!survey.!Next,!we!will!ask!you!questions!about!the!survey.!These!questions! will!focus!on!improving!the!survey!before!it!is!sent!out!to!the!general!public.!The!session!will!last!no! more!than!90!minutes.!There!will!be!10J14!participants!in!this!focus!group.!All!participants!are!over!18! years!of!age!and!live!in!western!Canada.!Notes!will!be!taken!based!on!the!discussion.!No!personal! identifiers!will!be!attached!to!any!data!recorded.!

Benefits:!You!will!be!given!$50!for!attending!the!focus!group!session.!!At!the!end!of!the!session!you! will!receive!your!earning!in!cash,!where!you!must!sign!a!receipt!for!it.!The!information!you!provide! will!lead!to!a!better!understanding!of!perceptions!of!forest!management.!

Risks:!There!are!no!anticipated!physical!or!psychological!risks!involved!with!the!focus!group.

Voluntary Participation:!Participation!in!this!study!is!voluntary.!You!may!decline!to!answer!any! questions!or!participate!in!any!part!of!the!study.!!You!may!decide!to!withdraw!from!this!study!at!any! time!without!any!penalty.!

Confidentiality:+No!personal!information!will!be!collected!as!part!of!the!data.!Your!name!will!only! appear!on!the!ethics!consent!form!and!your!payment!receipt.!All!other!information!recorded!will!be! anonymous.!Files!will!be!stored!in!a!locked!filing!cabinet!in!an!investigator's!office.!These!files!will!be! destroyed!after!5!years.!Only!the!investigators!and!Research!Ethics!Board!may!access!files!and!data.! Data!will!be!used!to!complete!a!graduate!student!thesis!and!a!report.!Policy!makers,!researchers,!and! industry!members!may!view!the!report.!Results!may!also!be!published!in!academic!journals.!If!you! would!like!a!summary!of!the!results!when!completed,!contact!Curtis!Rollins!(rollins1@ualberta.ca).!+

+

Further+Information:+If!you!have!any!questions!about!the!study,!please!contact!the!investigator,! Peter!Boxall!(pboxall@ualberta.ca!or!780J492J5694).!The!plan!for!this!study!has!been!reviewed!for!its! adherence!to!ethical!guidelines!by!a!Research!Ethics!Board!at!the!University!of!Alberta.!For!questions! regarding!participant!rights!and!ethical!conduct!of!research,!contact!the!Research!Ethics!Office!at! (780)!492J2615.!

+

Consent+to+Participate+in+this+Research+

My!signature!on!this!form!means!that:!

- This!optional!study!has!been!explained!to!me.!I!have!been!given!the!chance!to!discuss!it!and!ask! questions.!All!of!my!questions!have!been!answered!to!my!satisfaction,!
- I!have!read!each!page!of!this!form,!
- I!am!aware!of!the!risks!of!participating!in!this!optional!study,!
- I!voluntarily!consent!to!take!part!in!this!optional!study.!

Name%of%Participant%(Print)% % Signature%of%Participant% % Date%%

%

%

Curtis'Rollins'

Name%of%Person%Obtaining%Consent% (Print)% % Signature%of%Person%Obtaining%Consent% % Date%%

Focus Group (Round 2) Script

I. Introduction

- We appreciate you taking the time to come here to help us.
- Introductions of researchers
- Purpose of our meeting is for you to help us design a survey measuring preferences for new forest management policies. In particular, we will be focusing on preferences surrounding new tree breeding technologies for reforestation.
- The procedure is that you first complete a draft survey questionnaire and then (after everybody is done) we will have a discussion around the issues that are associated with the topic raised in the survey. Finally we will have a debriefing session, in which more information about the project itself will be communicated. Please feel free to help yourself to refreshment items at any time.
- If you have any questions about any issue related to the questionnaire, please mark it and raise it with us after everybody has completed.
- The questionnaire should take about 25 minutes to complete. The follow-up discussion will take around 40 minutes with 60 minutes as the maximum.
- The questionnaire survey is now in paper form. In final form it will be self-administered on a computer. Don't skip ahead or backward as the computer wouldn't let you skip.
- Before you begin to answer the questionnaire, please read the information and consent sheet. If you wish to participate, please sign it.

II. General

- General impression: Did you like the questionnaire? Please don't feel bad about hurting our feelings – we really want to know how you feel about the questionnaire. Resent it? Bored? Learn something? Hard to complete?
- Clarity: Did you have any trouble understanding the questions?
- Length: If it is too long, which part(s) you think are the least important so that we can consider where we can cut.
- Bias: Did the survey seem to push you to vote for one option versus the others? Did you understand the trade-offs inherent in the various options?

III. Introductory Discussion

A. Now we will go the through the questionnaire section by section:
   - Discuss section by section – ask about clarity of questions, information provision, etc.
   - Probe on how to ask tradeoff questions and avoid hypothetical bias.

B. Demographic Questions
   - Any other comments or question in this section?

C. Ask if there are any further comments or questions.

Thanks again for helping us with the design of this survey. Please leave all the materials here (surveys, pens, etc.) and collect your payment as you leave.

Appendix 3: Listing and Statistics of Attitudinal Indicators

Tables A.3.1 through A.3.8 list the mean responses and alpha coefficients for each psychometric scale, and item-rest correlations for each item. Item-rest correlation is the correlation between a specific item and all other items in a scale. Items for the New Ecological Paradigm (NEP), attitude toward science, and trust scales were answered on a 5-point Likert scale ranging from strongly disagree to strongly agree with a neutral mid-point. The trust scales and forestry and biotechnology knowledge scales also included a “don’t know” option, which was recoded as “uncertain” for the knowledge scales. A scale measuring respondents’ self-rated understanding of the tree breeding methods outlined in the questionnaire was answered on a 5-point Likert scale, with options “do not understand at all”, “understand very little”, “neutral”, “understand somewhat”, and “understand completely”. Aside from the forestry knowledge scale (α=0.1584), alpha coefficients for all scales are sufficient or better (greater than 0.7). However, as most of the scales were developed for different contexts, qualitatively and quantitatively examining the items is necessary to ensure each is relevant in the context of forest biotechnology acceptance. Further, it will likely be beneficial to reduce the number of items, as this also reduces the final model’s complexity, since each additional item requires five free parameters.

Responses to items comprising the NEP scale are listed in Table A.3.1. The NEP measures one’s subscription to the belief that humans are ecologically interdependent, rather than exempt from ecological forces. All odd-numbered items are in favor of the NEP, whereas even-numbered items measure the opposite and have been reverse-coded in the table for ease of comparison. The authors of the scale (Dunlap et al. 2000) suggest there may be five sub-scales within the NEP – limits to growth (N1, N6, and N11), that nature is balanced and susceptible to human interference (N3, N8, and N13), anti-anthropocentrism (N2, N7, and N12), non-exemption of humans from the law of nature (N4, N9, and N14), and belief in eco-crises (N5, N10, N15). When examining the sub-scales, the eco-crisis items exhibit that highest item-rest correlation, and are the only subscale with a sufficient alpha coefficient (α = 0.75). Thus, the eco-crisis sub-scale of the NEP will be used as a measure of environmental concern.

Table A.3.1 – Mean responses, item-rest correlations, and alpha coefficient of the New Ecological Paradigm (NEP) scale.

Item – NEP Scale	Mean	S. D.	Item-Rest Correlation
N1. We are approaching the limits of the number of people the earth can support.	3.46	1.03	.45
N2. Humans have the right to modify the environment to suit their needs.*	3.57	1.00	.47
N3. When humans interfere with nature it often produces disastrous consequences.	3.85	0.87	.46
N4. Human ingenuity will ensure that we will NOT make the earth unlivable.*	3.19	0.98	.43
N5. Humans are severely abusing the environment.[a]	3.99	0.91	.57
N6. The earth has plenty of natural resources if we just learn how to develop them.*	2.55	1.03	.32
N7. Plants and animals have as much right as humans to exist.	4.12	0.91	.46
N8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.*	3.70	0.92	.57
N9. Despite our special abilities humans are still subject to the laws of nature.	4.23	0.69	.28
N10. The so-called "environmental crisis" facing humankind has been greatly exaggerated.*[a]	3.48	1.07	.61
N11. The earth is like a spaceship with very limited room and resources.	3.68	0.97	.45
N12. Humans were meant to rule over the rest of nature.*	3.57	1.12	.45
N13. The balance of nature is very delicate and easily upset.	3.93	0.88	.49
N14. Humans will eventually learn enough about how nature works to be able to control it.*	3.37	0.99	.27
N15. If things continue on their present course, we will soon experience a major environmental catastrophe.[a]	3.73	0.96	.60
N=3456, α=0.8349			

* implies the item has been reverse-coded.

[a] denotes that the item was chosen for further analysis in the study.

Responses to the attitude toward science scale are presented in Table A.3.2. Since the goal is to measure how generally favorable respondents believe science to be, S1, S3, and S6 are less applicable than the other items. Items S1, S3, and S6 seem to be statements about science that do not necessarily imply a negative or positive view. Item S5 is problematic when the attitude toward science scale is analyzed alongside the trust scales, exhibiting high cross-loadings and residual correlations with other indicators. Thus, S2, S4, and S7, which have the three highest item-rest correlations, will be used to as indicators for the latent attitude toward science variable.

Table A.3.2 – Mean responses, item-rest correlations, and alpha coefficient of the attitude toward science scale.

Item – Science Attitude Scale	Mean	S. D.	Item-Rest Correlation
S1. Scientific knowledge builds up continuously.	4.26	0.69	.43
S2. Science is policy neutral.[a]	3.09	1.01	.57
S3. Science cannot be blamed for its misapplication.	3.34	1.04	.48
S4. Science is rational and unbiased.[a]	3.38	0.99	.63
S5. All science is good science.	2.77	1.07	.48
S6. Scientific inquiry can know no limits.	3.79	1.00	.48
S7. Some day, science will present the true picture of the world.[a]	3.51	0.95	.54
N=3456, α=0.7867			

[a] denotes that the item was chosen for further analysis in the study.

Results from scales measuring trust in industry, scientists, and the provincial and federal governments are listed in Tables A.3.3 through A.3.6. In each trust scale, the second item is dropped (useful source of information), as it is less relevant in this study than the other items. In some public acceptance of GM food studies examining trust, there is a focus on the impact of trust on which groups the public is likely to accept information from (Lang & Hallman 2005; Costa-Font et al. 2008). In the case of forest biotechnology policy acceptance, it is more relevant to focus on aspects of trust more directly related to forest management than on the dynamics of information provisions. When excluding the second indicator from each trust scale, underlying contributions of competence, transparency, public interest, and honesty to trust are still kept in tact. Using the first, third, and fourth items, each trust scale still has a coefficient alpha of 0.8 or greater. Of the four groups examined with respect to trust, the federal government is the least involved with forest management and will not be further analyzed.

Table A.3.3 - Mean responses, item-rest correlations, and alpha coefficient of the scale measuring trust in industry regarding forest management.

Trust in Industry Regarding Forest Management	Mean	S. D.	N	Item-Rest Correlation
TI1. Expertise to make a competent judgment.[a]	3.51	1.07	3384	.76
TI2. Useful source of information.	3.68	1.02	3392	.76
TI3. Will do what is right for society.[a]	3.17	1.11	3348	.82
TI4. Will tell the truth.[a]	3.00	1.12	3323	.78
α=0.9037				

[a] denotes that the item was chosen for further analysis in the study.

Table A.3.4 - Mean responses, item-rest correlations, and alpha coefficient of the scale measuring trust in scientists regarding forest management.

Trust in Scientists Regarding Forest Management	Mean	S. D.	N	Item-Rest Correlation
TS1. Expertise to make a competent judgment.[a]	3.98	0.79	3374	.70
TS2. Useful source of information.	4.10	0.75	3380	.69
TS3. Will do what is right for society.[a]	3.75	0.84	3339	.72
TS4. Will tell the truth.[a]	3.82	0.89	3336	.71
α=0.8592				

[a] denotes that the item was chosen for further analysis in the study.

Table A.3.5 - Mean responses, item-rest correlations, and alpha coefficient of the scale measuring trust in the provincial government regarding forest management.

Trust in Provincial Government Regarding Forest Management	Mean	S. D.	N	Item-Rest Correlation
TPG1. Expertise to make a competent judgment.[a]	2.77	1.04	3338	.71
TPG2. Useful source of information.	2.89	1.03	3324	.71
TPG3. Will do what is right for society.[a]	2.70	1.01	3312	.70
TPG4. Will tell the truth.[a]	2.48	0.98	3303	.74
α=0.9037				

[a] denotes that the item was chosen for further analysis in the study.

Table A.3.6 - Mean responses, item-rest correlations, and alpha coefficient of the scale measuring trust in the federal government regarding forest management.

Trust in Federal Government Regarding Forest Management	Mean	S. D.	N	Item-Rest Correlation
TFG1. Expertise to make a competent judgment.[a]	2.85	1.04	3346	.76
TFG2. Useful source of information.	2.98	1.02	3340	.77
TFG3. Will do what is right for society.[a]	2.77	1.00	3314	.79
TFG4. Will tell the truth.[a]	2.54	0.98	3302	.75
α=0.8989				

[a] denotes that the item was chosen for further analysis in the study.

Table A.3.7 lists results from the biotechnology knowledge scale. Items whose correct responses are “false” are reverse-coded, higher mean responses imply higher objective biotechnology knowledge scores. The eleventh item was added to the scale to examine knowledge of genetic manipulations of nature by humans via traditional breeding methods, but shares little correlation with the other scale items. Of the ten items in the original scale, items referring to GM food share noticeably higher item-rest correlations than the others. Further, in a principal components analysis of the ten items, two main factors are established (not shown). All GM-related items load strongly on the first factor, while the other items exhibit weaker loadings on the first factor and some exhibit very strong loadings on the second. Thus, it seems that the scale may be better interpreted as a scale measuring knowledge of genetic modification, dropping all non-GM related items. Of the GM-related items, two (BK4 and BK5) are specific to consequences of eating GM food, which is less relevant to forest biotechnology applications. Thus, it seems best to use items BK6, BK7, and BK10 to represent a measure of GM knowledge for the purpose of this study. However, this scale is only applicable in relation to the genetic engineering breeding method variable.

Table A.3.7 – Mean responses, item-rest correlations, and alpha coefficient of the knowledge of biotechnology scale.

Biotechnology Knowledge	Mean	S. D.	Item-Rest Correlation
BK1. The yeast used to make beer contains living organisms.	3.93	0.81	.34
BK2. The mother's genes determine whether the child is a girl.*	3.76	1.14	.28
BK3. The cloning of living things produces genetically identical copies.	3.61	0.94	.25
BK4. By eating a genetically modified fruit, a person's genes could also become modified.*	3.48	1.04	.45
BK5. Tomatoes genetically modified with genes from catfish would probably taste "fishy."*	3.46	0.89	.48
BK6. Ordinary tomatoes do not contain genes, while genetically modified tomatoes do.*[a]	3.61	0.97	.61
BK7. Genetically modified animals are always larger than ordinary animals.*[a]	3.33	0.95	.52
BK8. More than half the human genes are identical to those of chimpanzees.	3.61	0.89	.35
BK9. It is impossible to transfer animal genes into plants.*	3.18	0.90	.33
BK10. Genetically modified foods are created using radiation to create genetic mutations.*[a]	3.28	0.90	.48
BK11. Seedless bananas are the result of many generations of selective breeding.[b]	3.29	0.86	.07
N=3456, α=0.7478			

* Implies the item has been reverse-coded.
[a] Denotes that the item was chosen for further analysis in the study.
[b] This item is not part of the original scale, and was added to increase non-GE related items. However, it shares low correlation with the original scale items, and is excluded from the alpha score and further analysis.

Table A.3.8 presents results of the forestry knowledge scale. Due to the scale's low alpha coefficient and item-rest correlations, the scale should not be included in the analysis. The scale is not clearly measuring one underlying factor, and introducing it into a model will introduce more unexplained than explained variance.

Table A.3.8 – Mean responses, item-rest correlations, and alpha coefficient of the knowledge of forestry scale.

Forestry Knowledge	Mean	S. D.	Item-Rest Correlation
FK1. Forest companies are required to follow government guidelines when harvesting wood.	3.94	0.73	.1
FK2. There are no old-growth forests remaining in my province.*	3.55	0.88	.06
FK3. Most of my province's forested land is owned by the provincial government.	3.51	0.79	.14
FK4. Forest fires help the lodgepole pine open its cones and release its seeds.	3.62	0.86	.2
FK5. Clear-cutting is the most common method of harvesting trees in my province.	3.37	0.84	.01
FK6. All areas where trees are harvested must be replanted in order for the forest to return.*	1.98	0.94	-.08
N=3456, α=0.1584			

* implies the item has been reverse-coded.

Appendix 4: Threshold Estimates from ICLV Model

Table A.4.1 – Threshold parameter estimates for indicators of attitudes in the measurement sub-model of the ICLV model.

	Threshold Estimate			
Indicator	κ_1	κ_2	κ_3	κ_4
Trust Ind. 1	-3.334*	-1.988*	-1.026*	0.585*
Trust Ind. 2	-6.361*	-3.516*	-1.315*	1.845*
Trust Ind. 3	-4.414*	-2.332*	-0.480	1.724*
Science Att. 1	-2.646*	-0.889*	0.366*	1.702*
Science Att. 2	-4.546*	-2.101*	-0.335	2.383*
Science Att. 3	-2.551*	-1.416*	-0.276*	1.347*

*Implies estimate is significant at or above the 5% level.