Heterogeneity in Attitudes Underlying Preferences for Genomic Technology Producing Hybrid Poplars on Public Land

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Abstract

This study investigates the public preference heterogeneity of planting genetically improved poplar tree on public land for biofuel production 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 the new proposed forest policies to the current policy (base scenario). Proposed policies varied based on poplar breeding method (traditional, genomics, or genetic modification) and whether poplars may be used for biofuel production. A respondents' segmentation framework with cluster analysis and probit model was applied to data of respondents to uncover the heterogeneity of public's perception. The results of this study reveal that positive and negative perceptions about planting genetically improved poplar tree in the region create a division of respondents of somewhat supporters, somewhat opponents, opponents and supporters. British Colombians and Manitobans are identified as somewhat supporters and opponents of, respectively, the new policy of planting genetically improved poplar trees on public land. On the other hand, Saskatchewanians and Albertans are identified as supporters and somewhat opponents of, respectively, the new policy.

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1. Introduction

1.1 Background of the study

The forest industry is important to Canada providing a wide range of economic, social and environmental benefits. This industry contains three subsectors: solid wood product manufacturing, pulp and paper product manufacturing and timber harvest and silviculture. Each of these sectors has significant impacts on regional development, job creation, community stability and foreign exchange. Due to the various contributions of the forest industry to Canada's economy, governments continuously formulate and implement forest policies to enhance its' contributions towards the welfare of the general public (Tindall et al. 2013).

However, in recent years, Canada's forest industry has experienced a deep decline. This decline has been a result of a number of structural changes in world markets. For example, the world market timber production is heading towards the use of exotic trees from plantations which increase profitability; but Canada's forest industry is not following this trend. Moreover, the rise of electronic media has decreased the demand for paper by the communication industry. This has contributed significantly to the decline in the forest sector because paper production has been a driver of the Canadian pulp and paper subsector. To combat the decline in the forestry sector, one approach taken by the government has been to attempt to transform the sector by encouraging it to produce and develop new products. One of the new products being considered is the production of cellulosic biofuel from trees. This could involve planting genetically improved poplar trees on public land to produce biofuel (Natural Resources Canada, 2014).

However, there are several constraints associated with planting genetically improved poplar trees on public land in western Canada. For example, public land regulations state that replanting activities on public land require native trees which are produced from the collection of seeds harvested from parent trees that are growing locally. According to Natural Resources Canada (2012), Canada has strict seed harvesting policies in which regenerated native forests cannot include the planting of non-native trees. Tim et al. (2006) suggest that in most provinces of Canada, such as in Alberta, British Columbia, Manitoba and Saskatchewan, harvesting seeds and planting them on public land are rigorously controlled; provincial criteria only authorize the use of native species in which seeds are chosen from neighbouring areas.

Armstrong (2014) suggests that increasing investment in native trees plantations are financially infeasible. In contrast, there is evidence (e.g. Luckert et al. 2015) that returns from investments in non-indigenous species could be more attractive; and the use of these trees could enhance the economic efficiency of Canada's forest industry. Consequently, the opportunity costs of current public land regulations which involve planting solely native trees are high in most provinces of Canada.

There is public debate about the application of planting non-indigenous trees in Canada's forest industry. Those individuals against use of exotic or non-native tree plantation policies suggest that implementation of these polices could have negative impacts on forest biodiversity (Brockerhoff et al. 2008). On the other hand, Anderson et al. (2015) suggest that Canada's forest sector is sacrificing significantly high benefits from constraining the planting of these trees on public land.

Although there are no policies or regulations constraining the planting of non-native trees on private land, there are several economic and social factors that hinder the planting of these trees on private land. For example, Anderson et al. (2007) suggests that private lands are more costly to acquire and manage than public lands in Canada; and this makes implementing the development of exotic tree plantations on private lands financially infeasible.

Indeed, it is possible to enhance the profitability of Canada's forest sector and increase its contribution to the economy through reforming of the policy of not allowing the planting of exotic trees on public forest lands. One piece of information that would be needed to reform this kind of policy would be an understanding of the preferences of individual voters associated with the policy reforms. In order to examine whether the policy reforms are favored or disfavored by the public, a study was conducted by Rollins et al. (2015) that examined public preferences for the planting of exotic trees (specifically, genetically improved poplar trees) on public land for biofuel production in western Canada. The study was conducted in such a way as to also examine public preferences for the development and application of genetic modifications in planting forests affected by the forestry industry. The results from this study could provide evidence in support of changing the current policy that constrains planting exotic trees on public land.

Research suggests that individuals have different attitudes (i.e. heterogeneous preferences) associated with the applications of genetic modification to forestry; some people are in favor and others are against the technology. For example, numerous individuals have been protesting the use of forest biotechnology by motivating individuals to destroy experimental tree plots (Kaiser, 2001); and even laboratories involved in genetic research on forest trees (Service, 2001). On the other hand, Fillati et al. (1987) suggests that many individuals argue the application of biotechnology to forestry has various advantages, such as increasing the growth rates of trees, paper and biofuel production.

There are various factors that drive individuals to oppose or support the application of biotechnology; such as, knowledge, gender, presence of various information sources, perceived benefits and risks, and trust in government and scientists. For, example, lack of genuine information about genetically modified products may increase opposition to use of the technology while it brings several economic and environmental benefits. Wieczorek (2003) found that although biotechnology has substantial importance, environmentalists always portray the technology as having negative impacts on the environment, animal and human health; and they continue to motivate individuals against supporting the use of the technology. Further, Moon et al. (2004) found that public acceptance of biotechnology is significantly related to their perceptions of risks and benefits of genetically modified products, as well as their moral and ethical views. Gaskell et al. (2010) found that individuals with more knowledge and trust in governments in relation to genetic modification tend to support its application.

The successful implementation of newly proposed forest policies that permit planting of non-native trees on public land relies on the preferences of individuals to favour or not support use of biotechnology. Therefore, understanding interests and concerns of different segments of individuals of the public and the underlying factors that drive them to support or oppose the technology is important to make good decisions for the application of biotechnology to forestry.

In order to understand interests of different segments of individuals from western Canada for planting exotic trees (specifically genetically modified poplar trees) and examine the driving factors of these interests, the study has applied cluster analysis combined with probit models regressions. Cluster analysis is a technique which helps to categorize individuals based on similar characteristics; such as clustering individuals according to their preference similarities towards the application of biotechnology (Duran et al. 1974). The application of cluster analysis procedures to data on individuals (e.g. individual's choice of genetically modified products) divides survey of respondents into groups such that respondents in the same group have similar preferences, but preferences differ from those of respondents in other groups (Gwendolyn et al. 2007). Therefore, in this study, respondents who have similar preferences towards the application genetic modification in forestry are categorized in the same cluster. It helps to identify individual clusters who are proponents, opponents, or are neutral for the application of biotechnology to forestry in Canada. Moreover, it also helps to examine the factors that motivate individuals to hold negative perceptions to biotechnology; and to formulate targeted strategies that could enhance the acceptability of the technology among the opponents. For example, provision of genuine information, educational programs and trainings associated with understanding the technology can be tailored to specific clusters of individuals. William et al. (2006) suggest that clustering consumers according to their preferences towards genetically modified food (GMF) could show the variety of driving factors behind their stances and how to change factors that negatively motivate consumers to oppose GMF while it has importance to human and animal health.

Cluster analysis is rarely applied in the field of economics, especially applications to attitudinal data. The dearth of its application is surprising given the potential significance of such data for understanding individuals' behaviour in decision making, such as analysing various characteristics of consumers in the field of health science, economics and marketing. The reason for limited applications of cluster analysis in economics is indistinct. However, Gwendolyn et al. (2007) have suggested various reasons for the shortage of cluster analysis in the field of economics. For example, heterogeneity of individuals' preferences is best accounted for by including socio-economic explanatory variables in econometric models where the original economic model assumes all individuals are identical i.e. they have homogeneous preferences. Moreover, data from individuals' attitudes and personal value for a specific situation, such as survey data of individuals' attitude towards genetically modified products, are sometimes criticized due to a concern that such data are unreliable predictors of behavior. Finally, cluster analysis may be significantly exposed to subjectivity in numerous steps of statistical analysis. Considering these concerns and criticisms this study tries to examine the potential of cluster analysis to contribute to our understandings about the heterogeneity of individuals' preferences; specifically public preferences heterogeneity for planting genetically modified poplar trees in western Canada.

The results from probit models regressions could provide the likelihood of voting the newly proposed policy alternatives of poplar trees breeding which include traditional breeding, DNA breeding and Genetic modification where each of them are accompanied by whether or not poplars would be used for biofuel production. The marginal effects derived from this estimation could help to infer the responsiveness of members of each cluster for forest policy reforms taken by the federal and provincial governments in western Canada. This will also show which newly proposed forest policy is more preferred by members of each cluster relative to the current policy; and this in turn could indicate the ways that various authorities make effective decisions associated with forestry activities by considering preferences of different individuals groups.

We collected data from a survey of citizens in four provinces of Canada (Alberta, British Columbia, Manitoba and Saskatchewan). Cluster analysis is used to create clusters of respondents based on similarities of preference towards the application of genetic modification in the forest sector where individuals within cluster have homogeneous preferences and individuals across clusters have heterogeneous preferences. We then examine the responsiveness of respondents for policy change in support of biotechnological and policy innovation in the forestry sector within each cluster by applying probit models. Four distinct segments of respondents are identified; labelled somewhat supporters, somewhat opponents, opponents and supporters of the application of biotechnology to forestry.

1.2 Objectives of the Study

The overall goal of this research is to measure heterogeneity in preferences for planting genetically improved poplar trees on public land for biofuel production in western Canada. Specifically, the study attempts:

- To analyze sources of preference heterogeneity among clusters of individuals for improvements in poplar trees traits.
- To identify the main attitudinal factors which drive these clusters of individuals to support or oppose genetic modification in forestry.
- To examine the likelihood of members of each cluster to choose the newly proposed forest policies, specifically genetic modification, relative to the current policy (traditional breeding) in certain forest operations on public land.

2. Literature Review

While researchers have investigated public attitudes towards the application of biotechnology in food, few studies have been done that particularly investigate biotechnology applications in forestry. This gap likely emanates from the novelty of the application of genetic modification to forestry; and also because of less direct links of forests with the public than food or medicines do. Nevertheless, the public seems to perceive low levels of risk of the application of genetic modification to forestry and food than other ecological risks (Tait, 2007). Moreover, individuals' concern of applying biotechnology to forestry is changing overtime; as an example, Rollins et al. (2015) found that there are significant differences among individuals in terms of the level of acceptance of the applications of genetic modification to forestry in western Canada. The main driving factors for these variations are differences in knowledge and concerns of individuals in forestry.

Acceptance of biotechnology depends on various factors that correlate with or underlie individual citizens' reaction to the concept of genetic modification. For example, increased knowledge of genetic modification may increase consumers' acceptance of the technology (Zechendorf, 1994). Lower acceptance of genetic modification can also stem from risk perceptions (Heller, 2003). People's confidence in genetically modified food and trees are affected by trust in government and industry. Lack of confidence in controlling organizations leads individuals to more sceptical attitude towards genetic modification (Kel et al. 2003).

General attitudes as well as ethical and environmental concerns towards science and technology have positive and negative impacts on the acceptance of genetic modification technologies. For instance, Small et al. (2002) uncover that respondents tend not to agree that biotechnology is environmentally friendly, and ecocentric respondents (those that value nature intrinsically) tend not to support genetic engineering. On the other hand, Sheehy et al. (1998) conducted a survey and found out that respondents have positive reactions for the applications of genetic manipulations technology in the agricultural sector and its attribute for environmental benefits.

There is a greater degree of variation among males and females for the acceptance of genetically modified food. Gamble et al. (2010) suggest that women are less confident about genetically modified food than men, and are more likely to have changed their food purchasing behaviour due to concerns about it.

There have been many studies that attempted to categorise respondents by their reactions to genetically modified seeds and food. For example, cluster analysis of public's attitudes of genetic modification from a national survey in the UK found that 47% of the samples were 'Implacably opposed to biotechnology', 32% were 'Somewhat Opposed to biotechnology', and 12% had 'No Fixed Position on genetic engineering' (Heller, 2003). Bredahl (1999) found that consumers' reactions to genetic modification fell into three categories; refusers, undecideds, and triers. Research to measure farmers' preference for growing genetically improved oil-seed rape in Germany uncovered five segments of farmers of which 37% were supporters, 14% were economic skeptics, 29% were environmentally and socially influenced, 59% were die-hards and 5% were strongly opponents (Amos et al., 2009).

A large survey conducted in the U.S. categorized respondents into three groups based on their patterns of response towards biotechnology. Those who are

‘Supporters’ felt that biotechnology was useful, not risky, and acceptable; those who are ‘Risk tolerant supporters’ felt that it was useful but risky, as well as morally acceptable; and they also thought that it should be encouraged. Those who are ‘Opponents’ of biotechnology felt that it was not useful but is risky and unacceptable and consequently that its adoption should not be encouraged. A result of large European survey has identified four opinion groups based on perceived risks of the applications of biotechnology applications on human health and environment. The segments are trade-off respondents (18%) who saw risks and benefits from genetic modification; relaxed respondents (14%) who saw benefits and no risks, sceptical respondents (62%) who saw risks and no benefits, and uninterested respondents (6%) who saw neither risks nor benefits (Gaskell et al., 2009).

A review of research for the Canadian government identified five segments of respondents based on their attitudes towards biotechnology. The segments are true believers (21%), fearful supporters (23%), indecisive (32%), disinterested (6%) and 18% were opponents (Sheehy et al. 1998). Canadians viewed some aspects of biotechnology with suspicion, 63 % agreed that Canadians should be willing to accept minor risks when new products were released on the market. However, 37% of respondents felt that products should be guaranteed 100% risk free. Perception of benefits was highest for biotechnology products that had implications for human health and the treatment of disease; but slightly lower when the implications are for forestry (Veeman et al. 2003).

Harshaw (2012) identified three respondent groups in British Columbia based on their preferences for large-scale planting of poplar trees for biofuel production. The groups are those who agreed (29.5%), disagreed (63.5%) and were uncertain (27%) about the benefits and risks associated with the proposed policy options.

Socio-economic characteristics have significant impacts on the level of accepting genetically modified products. Janatki et al. (2010) uncovers that individuals with higher levels of education were more willing to accept the applications of biotechnology for forest biomass-based energy; while older respondents were less likely to accept the policy.

3. Methodology

This study uses data from a survey conducted by Rollins (2015) who gathered data from randomly recruited respondents in four provinces of Western Canada. The survey included opinion statements to measure respondents' attitudes towards biotechnology in forestry as well as questions regarding respondents' demographic and socio-economic characteristics. The respondents were given three poplar trees breeding methods which included traditional breeding, DNA breeding and genetic modification with the possible observed advantages of each method; and they were given the current public land regulations in their province associated with the plantations of poplar trees. Based on the available information, respondents were asked to vote among the different tree breeding methods. Totally, 3,456 respondents were selected from Alberta, British Columbia, Manitoba and Saskatchewan in which their age ranges from 18 to 90 years. After conducting the survey, cluster analysis (to identify segments of respondents) combined with a probit model (to measure the extent of preferences of individuals for genetic modification) are applied.

Different situational indicators, such as environmentalism, trust in scientists and governments, and knowledge of biotechnology, were included in the survey to capture individuals' attitudes associated with genetically modified poplar trees were used to create cluster of respondents. These types of variables are difficult to include in traditional models of choice behaviour due to possible issues of endogeneity and measurement error (Train et al. 1987). For example, a latent class choice approach would be a possible way to examine preference heterogeneity in these data, but using attitudinal information to define latent classes is problematic.

3.1 Questionnaire Design

Rollins (2015) provides detailed information on the design of the questionnaire and how it involved numerous stages of consultation with scientific experts from various fields of studies (geneticists, botanists, and forest scientists), as well as members from the general public. Initially, there were four focus groups to create a better understanding from the respondents by providing general ideas about the proposed policy options compared with the existing (current) policy. Participants for all public focus groups were recruited by random-digit-dialing by Advanis Inc., an

Edmonton-based market research firm. A total of 32 Albertans (16 from Edmonton and 17 from Grande Prairie) were included in two focus groups. A group of forestry experts evaluated the changes in value and the growth rate of poplar tree gained from various breeding methods. Based on the experts evaluation results hypothetical referenda were developed. 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.

Final round focus group discussion was held in Edmonton, Alberta (with 24 participants) and in North Battleford, Saskatchewan (with 22 participants) to ensure that all elements of the questionnaire were understood by the participants and to minimize potential sources of bias. Following the completion of these steps and some editorial tasks on 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 respondents were given more information about biofuels, different tree breeding methods, and the relevant province's current forest composition, industry, and policy; a series of hypothetical referendum questions and demographic information was collected last.

The hypothetical referenda involved six proposed policy alternatives, each of which were driven by two main attributes which are the tree breeding method employed, and whether or not poplars would be used for biofuel production. The first attribute was examined based on three tree breeding methods: traditional selective breeding, genomics-assisted breeding, and genetic modification. The three breeding methods appeared with and without a biofuel production attribute i.e. Traditional breeding with and without biofuel, genomics-assisted breeding with and without biofuel and genetic modification with and without biofuel production. Each respondent was given a chance to vote between the current policy (i.e. traditional without biofuel production) and the new proposed policy.

Respondents were given the two policy alternatives (current and new proposed policy). Figure 1 shows an example of the referendum question presented to the participants. In each policy alternative participants were given information regarding the location of parent trees, breeding methods, how commercial public land in their province is used, impact of the forest industry and the amount of carbon emission reduction from poplar biofuels in their province. The respondents were also given colored graphical and hyperlink information that provided definitions of each tree breeding method. In the base scenario, parent trees come from the same region as replanted trees; trees are bred traditionally, and there is no impact on jobs, income and carbon emission reduction. But the new proposed policies' parent trees could come from anywhere; they may have significant impact on jobs, income and carbon emission reduction in the particular province. Furthermore, assessments of commercial public forest land-use were given that consist of four elements: land with non-harvested forest and land with harvested coniferous trees, natural poplars, and improved poplars. There is a fixed (40%) harvested coniferous treed land in the referendum for both current and the new proposed policies.

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 using 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 (such as reports from Mistik Management Ltd. (2013) for Saskatchewan and Tolko Industries Ltd. (2014) for Manitoba). Simulation results from Anderson et al. (2012) were used to determine the expected changes in land-use due to allowing different breeding methods and worldwide seed selection on public land. In all proposed policy alternatives equal annual-allowable-cut (AAC) was taken into consideration where the same volume of timber is harvested in each policy alternative. Technically, higher tree growth rates might indicate a higher annual-allowable-cut (AAC) instead of leaving some areas unharvested, but a constant AAC was assumed to avoid confounding the area to be planted genetically improved poplars with different tree breeding methods.

Figure 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 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

Source: Rollins et al. (2015)

The combination of results from Anderson et al. (2012) with the experts' tree growth rates 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) were used to estimate the impact of allowing new tree breeding methods on the forest industry (jobs and income).

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 Vogel et al. (2008), and gasoline consumption data from Statistics Canada (2013).

3.2 Questionnaire Administration

Ipsos Canada (a market research firm) administered the questionnaire online to their online panel members in such a way to obtain a representative sample of citizens for Alberta, British Columbia, Manitoba, and Saskatchewan populations. Ipsos Canada (a market research firm), maintains a market research panel which consists of over 200,000 Canadians. These individuals can be selected and others recruited to develop samples that would be representative of the western Canadian population or smaller units such as the four provinces based on demographic information.

Respondents were chosen according to quotas on age, gender and municipality population. In order to minimize sampling bias, participants were given an incentive from Ipsos Canada without prior information to them. Although internet-based survey can be conducted more quickly, effectively, cheaply, than surveys conducted via conventional modes, it may encounter problems of sampling bias as well as some technical obstacles. For example, the respondents may browse the survey like they browse other websites and may face internet connection loss during completing the surveys (Ronald et al. 2009). Nonetheless, households' home internet access is increasing over time in each province considered in the study. For example, in Alberta it was 83% in 2010 and 89% in 2014. In general, currently, 86% of Canadians are accessing the internet at home (Canadian Internet Use Survey, 2014); therefore, the biases associated with internet accessibility might be minimized due to this situation.

3.3 Statistical Tools

3.3.1 Cluster Analysis

Cluster analysis is a technique applicable to situations involving data from a population where there exists some set of features or characteristics, in this study attitudinal variables, which may be used to separate the sample into groups or clusters that are similar with respect to certain characteristics (Duran et al. 1974). Those individuals which are categorized to the same cluster are required to be determined significantly similar, while those individuals who are assigned to different clusters are required to be determined significantly different based on their preferences towards genetically modified poplar trees. Cluster analysis is an exploratory tool which allows the analyst to search for different segments of respondents which may exist in the data (Salomon et al, 1982). The procedure is a multivariate statistical method that has been used to categorize objects or items based on the similarity or dissimilarity of the characteristics they possess; it also permits the minimisation of within group variance and maximisation of each group variance based on a range of research output indicators, resulting in heterogeneous groups each with homogeneous contents (Hair et al. 1998). For example, five individuals were observed in terms of their daily dollar expenditures on genetically modified food (X_1) and non-genetically modified food (X_2) as depicted in Table 1. The data from Table 1 are plotted in Figure 2 which shows that the five individuals' daily expenditures form two clusters.

Table 1: An illustration of clustering individuals based on similarity of daily expenditures on two types of food groups.

Individual	Daily expenditures ($)	
	Genetically modified food (X_1)	Non-genetically modified food (X_2)
a	2	4
b	8	2
c	9	3
d	1	5
e	8	5

Figure 2 shows that the first cluster comprises of individuals a and d, and the second cluster consists of individuals b, c and e. It is possible to infer that the observations in each cluster are similar to one another in terms of daily expenditures on GMO and NGMO, and the two clusters are significantly different from each other.

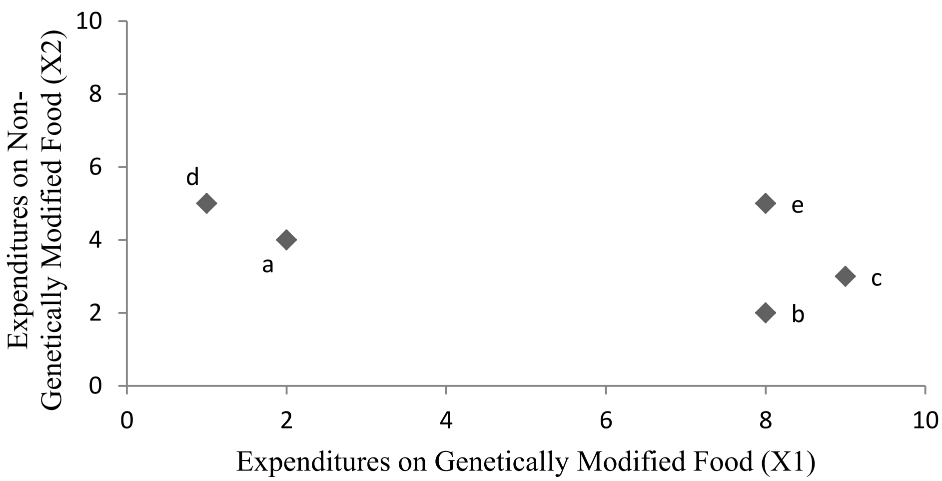

Figure 2: Clustering of data from daily expenditures on X_1 and X_2 (adapted from Peter, 1998)

Following this procedure, this study has clustered respondents based on various attitudes towards planting genetically modified poplar trees on public land for biofuel production in western Canada where respondents with similar preferences are categorized in the same cluster.

According to Peter (1998), distance measures between observations, such as the *Euclidean* distance, is a familiar concept in clustering processes. The *Euclidean* distance between observation of X_{1i} ; X_{2i}; .... X_{ki} and another observation of X_{1j} ; X_{2j}; .... X_{kj} is given by:

$$D(i,j) = \sqrt{(X_{1i} - X_{1j})^2 + (X_{2i} - X_{2j})^2 + \cdots \ldots \ldots \ldots \ldots .. + (X_{ki} - X_{kj})^2}$$

For example, considering Figure 3 as a map showing two points, i and j, with coordinates $(X_{1i},\ X_{2i})$ and $(X_{1j},\ X_{2j})$, respectively; the *Euclidean distance* between the two points is the hypotenuse of the triangle ABC given by:

$$D(i,j) = \sqrt{(\mathrm{A})^2 + (\mathrm{B})^2} = \sqrt{(X_{1i} - X_{1j})^2 + (X_{2i} - X_{2j})^2}$$

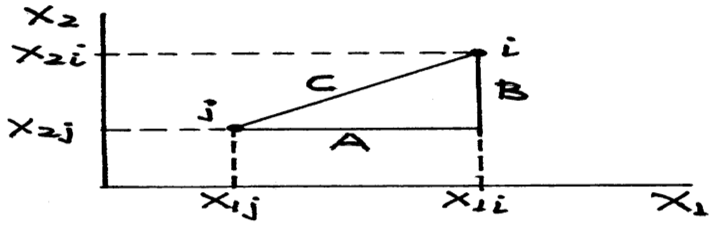

Figure 3: Distance measures between two observations (adapted from Peter, 1998).

Therefore, an observation i is declared to be closer (more similar) to j than to observation k if $D(i, j) < D(i, k)$. It is possible to apply this principle to survey of experiment where individuals are asked to vote for specific policy options; and categorize them based on similarity of their voting patterns. In this study, various elements which are related with several situational indicators that could capture respondents' attitudes associated with genetic modification are used as clustering factors; and this in turn could help to examine respondents' preferences towards planting genetically modified poplar trees. This includes indicators of respondents' opinions to science and research, the score derived from applying the New Ecological Paradigm (NEP), trust in federal and provincial governments, trust in scientists, trust in forest industry, trust in Environmental Non-governmental Organizations, knowledge of forest operations, and knowledge of biotechnology. Because the Euclidean distances are calculated using responses to these indicators, the distances provide measures of the differences in respondents' expressed to these situational variables. Therefore, respondents with closer values for these variables are grouped into the same cluster; which indicates respondents with closer preference patterns towards genetic modification could be assigned to the same cluster.

To identify clusters of respondents with similar attitudinal characteristics, such as knowledge of biotechnology, trust in government and environmentalism, for planting genetically improved poplar trees on public land for biofuel production, a two-step cluster analysis was used. According to Daniela (2010), in the first step of the two-step clustering procedure, respondents are pre-clustered into many small sub-clusters. Then, cluster the sub-clusters from the pre-cluster step into the desired number of clusters automatically based on similarity of some underlying variables within the sub-clusters, in this study, preferences similarity of planting genetically improved poplar trees. It has various advantages over other traditional clustering algorithms such as K-means, K-medians, Hierarchical and others clustering techniques where all these techniques involve manual determination of the number of clusters. It is capable of creating clusters based on both categorical and continuous variables; it selects the number of clusters automatically without any human intervention that could create bias in the number of clusters; and it is able to handle and analyze large data files efficiently.

In order to achieve the optimal number of clusters the two-step clustering approach was used. The clusters were created by considering various variables which are associated with different situational indicators. This includes indicators of respondents' opinions to science and research, the score derived from applying the New Ecological Paradigm (NEP), trust in federal and provincial governments, trust in scientists, trust in forest industry, trust in Environmental Non-governmental Organizations, knowledge of forest operations, and knowledge of biotechnology. Each indicator has a certain number of items; such as attitude towards science and research which has seven items (questions); indicators of the New Ecological Paradigm scale has 15 items; indicators of trust in federal and provincial government, scientists, forest industries and environmental non-governmental organizations (ENGOs) have 4 items each; and indicators of knowledge of biotechnology and forest operation have 10 items each.

There are statistical techniques to minimize the number (dimension) of items which have strong correlations among them so as to remove redundancy or duplication of variables. Factor analysis, sum of scale items and principal component analysis are commonly used techniques. Principal component analysis (PCA) is one way of identifying patterns in attitudinal scale data, and expresses the data in such a way as to highlight similarities and differences; and thus can be used to reduce the number of items (Watson, 2006). However, since principal component analysis compresses many scale items to fewer, some important information might be lost from the original items (Sasan et al. 2013). Nevertheless, the sum of each score (summed scale) do not loss potential information from the original items (Comrey et al. 1992). Summing scores is the simplest and desirable method of reducing items by preserving the variation in the original data (Black et al, 1998). Using the sum of raw scores for a set of items is a generally acceptable approach for most exploratory analysis (Tabeachinck et al., 2001).

To measure opinions towards science and research, respondents were given seven indicators in which they could rate on a five point Likert scale their level of agreement (from strongly disagree to strongly agree) where the highest score means they have more favorable opinions towards science. The New Ecological Paradigm (NEP), which shows the relationship between humans and the environment, has fifteen indicators. These basically measure respondents' environmentalism attitude. The highest scores given by the respondent indicate that the respondent thinks the environment is more important.

In order to infer trust in federal and provincial governments, scientists, the forest industry, and environmental non-government organizations (ENGOs) respondents were asked questions associated with forest management activities in their province. These activities include making competent judgements, provision of important information, making right decisions for society and telling the truth about managing forests in their province. All indicators were solicited on the basis of five point Likert scales where the highest score reveals that the respondent thinks provincial and federal governments play important roles in forest management; and the respondent has confidence in scientists, forest industry and ENGOs activities related with forest management. Knowledge of forest operations and biotechnology indicators are also included.

To measure knowledge of forest operations, six facts (statements) which are related to forest management requirements and practices in respondents' provinces were provided with "agree", "disagree" and "don't know" choices in order to provide information on their knowledge about existing forest practices. Respondents' knowledge of biotechnology was predicted by providing ten items which described various breeding and genetic modification practices. Respondents provided one of three choices “agree”, “disagree” and “don’t know”. During cluster formation, these knowledge predictors were included by taking the percentage of correctly answered statements for each respondent.

3.4 Econometric Methods

After generating significantly different clusters of respondents, probit regressions are applied to each cluster to examine the likelihood of choosing a specific policy option by members of a given cluster. The results from a probit model could indicate how respondents across clusters are varied in terms of their responsiveness to changes taken by the forest sector i.e., the application of biotechnology in forestry. The econometric model specification is based on the work of Dan et al. (2003). Binary probit specification for the vote choice equation and multiple responses per respondent are used. The random utility theory proposes that individual consumers choose alternatives that yield the greatest utility and so the probability of selecting an alternative increases as the utility associated with it increases (Trevor et al. 2001). Equation 1 represents the respondent’s utility level associated with the choice of an alternative, ‘j’, which consists a deterministic (observable) component (V_j), and unobservable (stochastic) component (e_j):

$$U_j = V_j + e_j \qquad (1)$$

Where; V_j is the indirect utility function and e_j is a random component. Moreover, it is noteworthy to know utility is stochastic from the researcher’s point of view, but not the respondent. When the dependent variable is binary, formally, consumers will choose alternative ‘j’ over alternative ‘k’ if $U_j > U_k$ (Kara et al. 2009).

The aim of this study is to investigate possible sources of preference heterogeneity among individuals by applying cluster analysis to various attitudinal indicators. Let ‘n’ be a respondent found in cluster ‘c’ who chooses a new policy alternative ‘j’. Hence, $P_{ncj} = 1$, represents respondent ‘n’ who resides in cluster ‘c’ who voted for the new proposed policy alternative over the current policy; while $P_{ncj} = 0$ represents a respondent ‘n’ who resides in cluster ‘c’ who voted for the current policy over the new proposed one. Therefore, U_{ncj} is the unobserved (latent) utility gained by respondent 'n' in cluster 'c' associated with voting for the new proposed policy alternative 'j'. Mathematically this can be represented by:

$$U_{ncj} = a_c + \theta_c{}'J + \nu_{nc} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$P_{ncJ} = 1 \text{ if } U_{ncJ} > 0, \text{ and } P_{ncJ} = 0 \text{ else.}$$

Where; U_{ncJ} is the utility of voting for a new policy by 'n' in cluster 'c' over the current policy; P_{ncJ} is the observed vote choice of 'n' in cluster 'c' for policy alternative 'J' (1 = new policy, 0 = current policy); J is a choice scenario (i.e. traditional breeding, DNA breeding, genetic modification and biofuel) provided to all respondents; ν_{nc} is a normally distributed and cluster specific error term; c is one cluster in a number clusters, c = 1, 2, 3,…, Z; n is a respondent in the sample of survey data, and a_c and θ_c are parameters to be estimated in each cluster.

The analysis is conducted using poplar trees as the product that is subjected to genetic modification. Public approval of the three policy alternatives is compared against the benchmark scenario where traditional poplar tree breeding is employed and the resulting fiber is not for cellulosic biofuel production. This comparison provides information and understanding of the level of public support, in each cluster, for the use of genetically improved poplar trees in public land forestry. Therefore, in this study, by taking traditional breeding with no biofuel as the base policy scenario and using DNA breeding, genetic modification and biofuel production as the new possible policy alternatives, the probit model is applied.

Cluster analysis with a probit model can provide meaningful results related to preference heterogeneity in respondents choice behaviour and the extent to which they prefer a specific policy option. To the best of the author's knowledge, this is the first study to apply cluster analysis combined with probit models to measure public preference heterogeneity towards genetically improved poplar trees for biofuel production. Therefore, the results will explain preference heterogeneity of various segments of the public. These findings can then be used to provide information and guidelines for more effective and efficient forest management strategies which include the preferences of various individual groups.

4. Results and Discussion

4.1 Cluster Identification

By applying two-step clustering techniques, four distinct clusters of respondents were generated in which cluster 1, 2, 3 and 4 have 1,079, 1,056, 439 and 882 respondents respectively. The two-step cluster analysis provides three ranges (poor, fair and good) to measure the overall quality of the clustering process. Kaufman et al. (2005) suggest the use of a silhouette algorithm that measures cluster cohesion and separation and shows how closely related the objects within each cluster are and how distinct or well separated a cluster is from other clusters. It also shows the average dissimilarity of observation i with all other observations within the same cluster; where the smaller average value indicates the better assignment of the observation to a given cluster. Let $a(i)$ be the average dissimilarity of observation i in one cluster and $c(i)$ be the lowest average dissimilarity of observation i to any other cluster, of which i is not a member. The cluster with this lowest average dissimilarity is said to be the "neighbouring cluster" of i because it is the next best fit cluster for this observation. Hence, the silhouette of observation $i, s(i)$, can be defined as:

$$s(i) = \frac{c(i)-a(i)}{\max\{a(i),c(i)\}}$$

This can also be written as:

$$s(i) = \begin{cases} 1 - a(i)/b(i)\,, & if\ a(i) < c(i) \\ 0, & if\ a(i) = c(i) \\ c(i)/a(i) - 1\,, & if\ a(i) > c(i) \end{cases}$$

From the above two equations, it is possible to conclude that $-1 \leq s(i) \leq 1$. When $s(i)$ is close to 1, observation i is well matched to a given cluster; which in turn indicates the clustering procedure was appropriate; and vice versa when $s(i)$ approaches to -1. Therefore, the quality of clustering process in this research falls in the "good" range (approaches 1), as depicted in Figure 4, which indicates that respondents within each cluster have closely similar patterns of characteristics, and those across clusters have different characteristics.

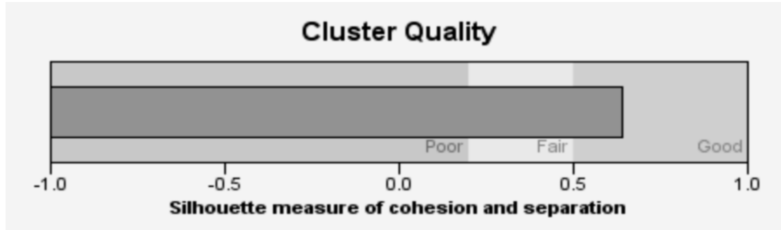

Figure 4: Overall model quality of clustering.

The pie chart in Figure 5 below shows the percent distribution of the total number of respondents among the four clusters. Clusters 1, 2, 3 and 4 comprise 31.2%, 30.6%, 12.7% and 25.5%, respectively, of the total number of respondents; cluster 1 and 3 contain the highest and lowest proportions of the total number of respondents.

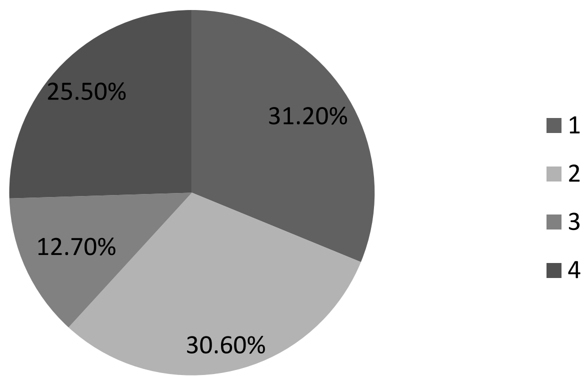

Figure 5: Cluster Distribution.

Table 2 below depicts the total number of respondents, as well as the mean and percentage values of certain variables. Cluster 1 contains the highest (41.6%) and lowest percentages of British Columbians and Saskatchewanians (12.5%); respectively. Albertans and Manitobans comprise the highest (41.6%) and lowest (13.2%), respectively, percentages in cluster 2. In all clusters, the number of rural dwellers and non-farmers is less than the number of urban dwellers and farmers.

Table 2: Mean values, number and percentages of variables by cluster

Variables	Cluster				
	1	2	3	4	Total
Number of Respondents	1,079	1,056	439	882	3,456
Percentage of total sample	31.2	30.6	12.7	25.5	100
Rural dwellers	340	292	149	294	1,075
Urban dwellers	739	764	290	588	2,381
Number of farmers	40	66	14	33	153
Non-farm	1,039	990	425	849	3,303
Albertan (%)	29.8	41.6	17	34.2	30.6
British Columbian (%)	41.6	23.7	34.4	15.7	28.8
Manitoban (%)	16.1	13.2	38.2	11.1	19.7
Saskatchewanian (%)	12.5	21.5	10.4	39	20.9

4.2 Importance of Predictors in each Cluster

The next four bar charts graphically present the importance of each clustering variable in the creation of the clusters where all factors are measured in terms their mean value. Figure 6 shows that respondents who fall into cluster 1 demonstrate high tendencies of trust in environmental non-governmental organisations (ENGOs). This factor takes the highest share in the make-up of this cluster. The NEP score is the second most important element in the formation of this cluster. Respondents in this cluster are well informed about biotechnology and forest operations which are reflected by the mean values associated with these factors. Other variables, especially, trust in federal and provincial governments, scientists and the forest industry have small levels of importance on membership in cluster 1 since these respondents mainly rely on ENGOs information. As shown below, compared with the other clusters, cluster 1 respondents generally have the highest mean values for trust in ENGOs, attitudes towards science and research, trust in scientists and environmentalism perceptions.

Figure 6 shows the importance of the factors in the make-up of cluster two. For cluster two respondents, significant clustering factors that influence membership are knowledge of biotechnology and forest operations, as well as the New Ecological Paradigm score. Trust in different forest management organizations is the least important (insignificant) factor for the make-up of cluster 2.

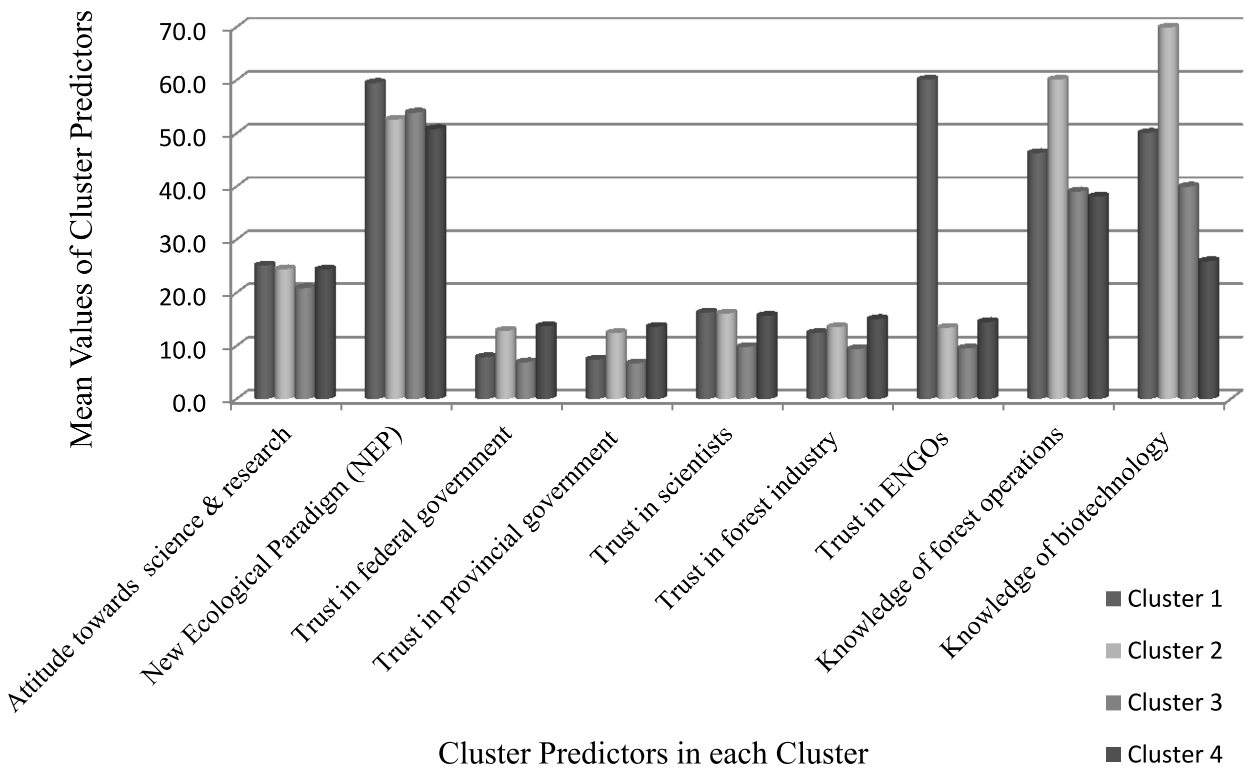

Figure 6: Predictors importance in each cluster.

Nevertheless, members in this cluster have higher trust in federal and provincial governments, and trust in the forest industry than members of clusters 2 and 3. In general, those who are assigned to this cluster hold more information about biotechnology (70%) and forest operations (60%) than those in all of the other three clusters.

Figure 6 shows the level of importance of clustering variables for cluster 3. The most important factor in the membership of this cluster is the New Ecological Paradigm score. Respondents in this cluster have similar environmental perceptions with those in cluster two. However, trust in various forest management organisations and scientists, as well as mean values of attitudes towards science & research are the lowest compared with the other clusters. This group of individuals hold high environmentalism views. According to Greenpeace[1] (2012), there is growing evidence that genetic engineering poses new hazards to ecosystems, with the potential to threaten biodiversity, wildlife and truly sustainable forms of agriculture. In addition, it is thought that once GE organisms are released into the environment they may transfer their characteristics to other organisms and can never be recalled or contained.

Figure 6 shows the importance of clustering factors in the make-up of cluster 4. Although the NEP score, knowledge of forest operations, attitudes towards science and research, and knowledge of biotechnology are the most significant elements in the formulation of this cluster, they have lower mean values than they do in other clusters. However, members of this cluster have the highest mean values of trust in the forest industry, and in the federal and provincial governments compared with the other clusters

There is a positive relationship between consumers' trust in government and their acceptance towards biotechnology applications. Consumers' acceptance of genetic engineering consistently increases with the rise of their trust in government (Jikun et al. 2010). It is important to note that in Figure 6 the New Ecological Paradigm, knowledge of forest operations and biotechnology seem to have the highest predictor importance in all clusters. This is because the NEP has 15 questions that are scaled in five point Likert scale from *strongly disagree* (1) to *strongly agree* (5). Thus, the minimum and maximum sum of the scale items are 15 and 75 respectively.

For knowledge of forest operations and biotechnology the percentages of *correctly answered* questions were considered in which the minimum and maximum percentages are 16 % and 100% (for knowledge of forest operations) and 10% and 100% (for knowledge of biotechnology), respectively. However, there are important

[1] Greenpeace is a non-governmental environmental organisation with offices in over forty countries. Its aim is to raise public knowledge of environmental issues related with genetic modification, deforestation and climate change; and influencing both the private and the public sector (David et al. 2010).

differences in the values of these clustering factors between the four clusters. Table 3 gives the exact values for each factor for each cluster and provides a tabular summary of the information contained in previous four figures.

Table 3: A summary of mean values of variables used in defining clusters of respondents

Cluster Factors	Mean			
	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Attitude towards science & research	25.1	24.4	20.85	24.32
New Ecological Paradigm (NEP)	59.45	52.56	53.87	50.79
Trust in federal government	7.85	12.8	6.89	13.67
Trust in provincial government	7.39	12.39	6.7	13.56
Trust in scientists	16.23	16.07	9.77	15.63
Trust in forest industry	12.38	13.49	9.36	15.02
Trust in ENGOs	60.07	13.38	9.5	14.47
Knowledge of forest operations	46.25	60.07	39.03	38.05
Knowledge of biotechnology	50.06	69.88	39.95	25.91

4.3 Relationships between Demographic Characteristics and Cluster Membership

It is important to examine how members in each cluster differ in terms of the demographic characteristics of the participants. The results of the cluster analysis distinguished four main respondent groups, which do not differ significantly in terms of age of the respondents. This suggests that whether someone opposes or supports the new policy alternatives is likely not to be determined by their age. Thus, respondents of all ages can belong to any of the four clusters identified. This finding contradicts studies by earlier researchers, such as Fitzgerald et al. (2003), who observed that the percentage of adults was almost three times that of youth respondents who were against biotechnology in food.

The level of education is found to have a significant influence on which cluster a respondent belongs. We observe that most of respondents who are in cluster 4 have supportive attitudes of the application genetic modification and constitute a higher percentage of respondents with high levels of education than those who are in cluster 3 with opposing attitudes of the technology.

Table 4: A summary of demographic variables in each cluster

Variables		Cluster				
		1	2	3	4	Total
Age Distribution of Respondents (%)	18 – 34	19.5	23.4	20.1	28	22.7
	35 – 64	62.4	60.8	64.5	58.2	61.5
	65^{+}	18.1	15.8	15.4	13.8	15.8
Education level Distribution (%)	High School	19	16	26.8	27	22.2
	College	50	42.4	47.6	48	47
	Undergraduate	22	28.8	18.9	18	21.9
	Graduate	9	12.8	6.7	7	8.9
Number of male		369	526	195	376	1,466
Number of female		710	530	244	506	1,990

Breustedt et al. (2008) confirm in their study that there is a close connection between education and genetic engineering in which education has a positive impact on the level of acceptance of genetic manipulation. A high level of education is associated with the acceptance of GM benefits, and conversely the opposite holds for high levels of perceived risks (Traill et al. 2004). Fletcher et al. (1991), suggest that education has a direct relationship with the acceptance level of genetic manipulations for forest-oriented biofuel. Weaver (2005) concludes that education level has negative impacts on the acceptance level of biotechnology indicating that respondents with high education are more likely to reject GM. There is an unclear association between acceptance of genetic modification and individuals' education and knowledge level, income level, moral and ethical considerations for food (Veeman et al. 2005). Within cluster 3, the percentage of females is higher than males suggesting that females are more likely to be against biotechnology applications than males. In cluster four, the number of females is greater than males which could imply that more females support the application of genetic engineering. Hossain et al. (2012) confirms that differences between males and females in acceptance of biotechnology are insignificant but that females are slightly more opposed. Kozak et al. (2014), suggest that the application of genetic modification in forestry applications is inadequately described by demographic variables. Males were relatively more likely to accept genetically modified trees than females.

4.4 Profiles of Clusters

Table 5 shows that Cluster 1 respondents are in favour of current policy (60.43%); compared with genetic modification (39.57%). Moreover, they have lower preference for DNA breeding (40.22%) than traditional breeding (59.78%); and also they prefer new policies with biofuel production (53.39%) than the current policy (46.61%). Those individuals who are assigned in cluster 2 have indifferent preferences for DNA and traditional breeding methods; and current policy (traditional breeding) alternative in which the percentages of voting for these alternatives are reasonably similar (50%); though they are against genetic manipulation without biofuel production scenario (47.5%).

Table 5: Relative percentage of vote in support of new forest policy alternatives in each cluster

Policy alternatives	Percentage of respondents in each cluster			
	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Voted for DNA breeding (%)	40.22	50.38	40.09	50.11
Voted for genetic modification (%)	39.57	47.50	37.29	51.53
Voted for biofuel (%)	53.39	61.14	42.52	59.45

** All figures are relative to traditional breeding (the base scenario)[2]

They have highest preferences for new policies with biofuel production (61.14%) than the existing policy (38.86%). Respondents in Cluster 3 are more against the new policy alternatives than the existing policy option. Furthermore, it is possible to conclude that they are more against genetic manipulation (37.29%) compared with

[2] The vote percentages of traditional breeding relative to DNA breeding, genetic modification and biofuel in cluster 1 are 59.78, 60.43 and 46.61; in cluster 2 are 49.62, 52.5 and 38.86; in cluster 3 are 59.91, 62.71 and 57.48; and in cluster 4 are 49.89, 48.47 and 40.55 respectively.

biofuel production and DNA poplar tree breeding methods. Cluster 4 respondents are supporters of new policy alternatives. They have similar preference patterns with those in Cluster 2 and have identical preferences for DNA breeding methods (nearly 50%). But, respondents in this cluster prefer genetic manipulation more than the current policy (48.47%), unlike those in Cluster 2. In addition, they have higher preferences for biofuel production than those respondents in cluster 1 and 3 as depicted in Table 5.

The next step is to interpret the clusters by assigning a label that appropriately describes the nature and characteristics of the clusters regarding their views of biotechnology in forestry and changes in forest policy. As the cluster analysis was performed by using the summed scale of cluster predictors, the interpretation of the clusters is mainly associated with inspecting the mean values of the original questions (items). Since respondents in Cluster 1 paid the lowest and highest levels of attention for genetic modification and biofuel production, and they seemed to be in favour of the new policy if it is only accompanied with biofuel production; Cluster 1 is labeled as "*Somewhat in support*" of the new policy alternatives. Cluster 2 is named as ‘‘*Somewhat in opposition*" since these respondents chose a high value of importance towards DNA breeding and biofuel production. Cluster 3 is labeled as ‘‘*Opponents*" as they have the highest voting percentages for traditional breeding (i.e. the base scenario). Finally, Cluster 4 is named as "*Supporters*" of the new policy alternatives in which they have lowest voting percentage of the base scenario which represents current forest policy which utilizes traditional breeding methods.

Cluster 1 contains the highest proportion of the total number of respondents at 31.2% (Table 1). Respondents assigned to this cluster are identified as *somewhat supporters* indicating that they are not completely against the policy of planting genetically improved poplar trees on public land for biofuel production. They are in favour of biofuel production; however, they are against genetic modification and DNA breeding relative to traditional poplar breeding method (the base scenario).

Figure 6 depicts that attitude towards science and research, trust in scientists, federal and provincial government have less importance in the make-up of this cluster. Skepticism of respondents towards genetic modification could emanate from these attitudinal variables. There is mixed empirical evidence that links trust with public support for biotechnology. For example, Finlay et al. (1999) found an insignificant effect of trust on public support, while Rusanen (2003) showed positive and significant effects of trust on public support of genetic engineering. Harvey (2006) trust in scientists has a significant effect on the public acceptance of genetic engineering. In addition, respondents in this cluster mainly rely on ENGOs and have environmentalism attitudes. Environmental organisations are continuously promoting the negative consequences of biotechnology. A study by Wieczorek (2003) shows that environmentalists feel that inadequate effort has been made to understand the dangers in the use of transgenic crops, including their potential long-term impacts. They have demanded the abandonment of genetic engineering research and development. Therefore, if individuals have trusts in these organisations they are more open to rely on the information provided by these institutions and tend to have reluctant attitudes towards the application of biotechnology.

Respondents assigned to *somewhat supporters* tend to hold higher mean values of knowledge of biotechnology and forest operations showing that the acceptance level of the application of genetic modification has an inverse relationship with knowledge variables. Sholdere (2003) suggested that good knowledge decreases the level of biotechnology acceptance, since the high level of knowledge encourages individuals to ask more critical questions about genetic manipulations that result with more sceptical attitude. On the other hand, Hoban (1997) uncovered a significant and positive relationship between individuals' preferences and attitudes regarding biotechnology and the level of knowledge. Chaya et al. (1995), suggest that consumers in numbers of different nations and their results showed that, in spite of dearth of knowledge, views towards biotechnology were more positive; implying that as the level of people's knowledge is increased the level of acceptance of genetically modified products also is enhanced by a significant extent.

Somewhat supporters have higher mean values of knowledge of forest operations and trust in forest industries. A study by Earle et al. (1995) shows that the readiness to rely on forest industry's policies and decisions of agencies and their employees has been found to be important to environmental risk perception and to accepting emerging biotechnologies and environmental management. Hence, *somewhat supporters* have positive opinions for biotechnology applications on poplar tree breeding. This can arise from knowledge of forest management practices and trust in forest industries which in turn make *somewhat supporters* more supportive of at least one new policy alternative.

Middle and young age group respondents comprise the first and second, respectively, highest percentages of age distribution in this cluster; and older aged participants have the least percentage. Many survey experiments have been done to measure the degree of acceptance of genetically modified trees and foods among different age groups. For example, Ferdaus et al. (2002) young consumers (age less than 35 years) are more skeptical of biotechnology than the middle aged and older individuals. Most of the middle aged respondents are biotechnology learners and self-protectors, whereas older consumers are either self-protectors or benefit seekers. This contradicts with the results from Onyango et al. (2004) which suggest that young respondents are more likely to consume genetically improved plant and animal food products than middle-aged respondents.

A higher percentage of respondents in this cluster also reside in urban areas. Consequently, respondents in this cluster have reluctant attitudes towards the genetically improved poplar trees. This result contradicts with the findings of Huang et al. (2006) where many Chinese who are located in urban areas haven't great resistance for the commercialisation of genetic modification. On the other hand, Jane et al. (2014) claims that respondents from more rural counties are more likely to be familiar with genetic modification than their urban counterparts. They found a trend towards increased awareness over time since the early 2000s, as evidenced by the more recent survey year variables.

Somewhat supporters comprised the highest number of respondents who are engaged in non-farm activities. The connection of farmers with biotechnology is typically higher than those who are non-farmers. Since individuals who are engaged in non-farm occupations have less information and direct connections with genetic engineering unlike the farmers, the probability that these individuals to only tentatively support biotechnology is high (i.e. the likelihood to be a *somewhat supporter* of genetic modification is high). A study by Ian et al. (2009) shows that farmers have been increasingly consulted regarding their perceptions about genetic modification in relation with environmental, social and economic impacts. Farmers are interviewed many times regarding biotechnology; have participated in various agricultural forums and they also have taken various trainings in relation to the technology. Therefore, the tendency of urban dwellers to fall in a *somewhat supporter* category might arise from lack of potential connection and information associated with biotechnology.

About 41.3% of the members of *somewhat supporter* cluster reside in British Columbia. Canseco (2014) shows that British Columbians have little appetite for genetic modification; they hold genetically modified crops and food in low regard, and a sizeable proportion of residents in this province would support banning them from Canadian store shelves. Canseco empirically shows that about 66% of British Columbians, based on an online survey, have a negative opinion regarding biotechnology.

Albertans comprise the second (29.7%) highest percentage of membership in the *somewhat supporter* group; Manitobans and Saskatchewanians have the least percentages of respondents in this cluster at; 15.9 % and 13.1% respectively. A survey study by David et al. (2006) to measure the public perceptions for the application of genetic modification, specifically, in Saskatchewan and generally in Western Canada shows that Saskatchewanians support the biotechnology applications.

Fifty percent of the respondents have a college degree; and those who have high-school, undergraduate and graduate level of education consist of 19%, 22% and 9% respectively. People with higher level of education have positive opinions towards biotechnology and they will not be extreme opponents of the technology. This result can be confirmed by research done by David et al. (2006) which suggests the more people know about biotechnology, the more they are in favor of the technology. In opposition, it is possible to find that an inverse relationship between the level of education and the acceptance level of genetically improved plants and foods from various survey experiments (e.g. Sholdere 2003).

Cluster 2 comprises the second highest proportion of the total respondents (30.6%); and respondents in this cluster are labeled as *somewhat opponents* of the application of biotechnology to forestry. The scores from the new ecological paradigm, knowledge of forest operations and biotechnology have higher mean values in this cluster. The reasons why respondents in this cluster are not strong supporters of the newly proposed policy could originate from these factors. When individuals have environmentalism attitudes, the likelihood of refusing genetic engineering will be significant. Many studies articulate that environmentalists put numerous standards on biotechnology before it becomes practical. For example, Kaiser (2001) shows that tree engineering is coming "*under fire*" from environmental groups as it has moved from the laboratory into the field-testing stage. The development and application of transgenic trees has arrived at a critical juncture now that scientific progress has brought their use in commercial plantations within reach (Mann et al. 2002); thus, environmental concerns are becoming the main obstacles to public acceptance and regulatory approval. Opponents are calling for a suspension of commercial release of genetically modified food and plants until long-term environmental impacts are better assessed and understood; and a stronger research-based regulatory framework is in place (Campbell et al. 2001).

This cluster contains the highest percentage of respondents who have undergraduate (28.8%) and graduate (12.8%) levels of education. This could be the main reason for having the highest mean values of knowledge of biotechnology and forest operations indicating that respondents in this cluster have answered many statements correctly associated with forestry activities and biotechnology. Many experimental survey results, for example, David et al. (2006) show that participants with higher levels of education usually answer survey questions related with biotechnology correctly.

About 38.4% of the members of *somewhat opponents* cluster reside in Alberta. This implies that Albertans are identified as *somewhat opposed* to planting genetically improved poplar trees on public land for biofuel production. This contradicts with the research result by Mario (2014) which concludes that Albertans are against genetic modification and they perceive that genetically modified food and crops are “unhealthy”. Most of the respondents in this cluster are engaged in non-farming activities and they live in urban areas. There is no large gender distribution difference within this cluster; i.e. the proportion of females and males are equal. Manitobans have the smallest percentage of the total participants in this cluster.

Cluster 3 has the smallest number of respondents (12.7%); and about 37% of these members are from Manitoba. This shows that Manitobans are against the newly proposed policy alternatives aiming at planting genetically improved poplar tree for biofuel production. All clustering factors except new ecological paradigm have lower mean values in this cluster. The values of the new ecological paradigm have a greater mean value in the make-up this cluster of respondents (i.e. *opponents* have more environmentalism attitudes). These figures fit with many theoretical and empirical findings by various researchers. For example, Blay (2005) suggests that a number of objections against biotechnology by environmentalists are based on the negative impact of genetically modified plant’s cells and pollen on nature in which they argue that there is a massive and long-run intoxication of the environment.

The rejection of genetic modification by respondents can arise from different reasons including loss of trust in government and scientists, lack of information and knowledge, and perceived risks associated with genetic engineering (David et al. 2006). The opponents argue that plant genetic engineering is an interference of nature and may have unknown and disastrous consequences (Nelson, 2001); Onyango et al., (2004), find that people who are against biotechnology applications in plants have further strengthened their opposition by arguing that genetic modification to food and seeds may have the tendency to contaminate the non-GM plants, such as organic seeds and foods through processes like pollination.

Public acceptance of biotechnology has multiple dimensions and is influenced by multiple factors. For example, people expect various benefits from genetic modification to forestry which include enhancement of bio-based products, reduce invasive threats, maximization of forest productivity, creation of environmental balance and the replenishment of indigenous values and forest resources. In addition, the public expects more benefits from genetically modified foods which have direct associations with health, nutritional values and quality and quantity of food items. Hence, the expected benefits from the application of genetic modification promote the acceptance of this technology. Conversely, the expected risks related with humans and the environments are likely to discourage its acceptance. According to Hallman et al. (2008), some society share negative image of biotechnology companies and quite skeptical of government's ability to properly regulate genetically modified products.

This cluster has the lowest percentage of respondents with graduate level of education. Manitobans comprise the highest share of respondents in this cluster; while Saskatchewanians take the lowest proportion. Moreover, this cluster has the highest proportion of high school level of education and the middle-age (between 34 and 64 years old) group. The number of respondents who are engaged in farming activities is lowest in this cluster.

Finally, Cluster 4 is the third highest in terms of the number of respondents which comprises 25.5% of the total number of participants. Respondents assigned to this cluster are named as *supporters* of planting genetically improved poplar trees on public land for biofuel production. These respondents have optimistic attitudes towards biotechnology; and they have lower values for the new ecological paradigm which measures environmentalism attitudes. Nevertheless, this doesn't mean that *supporters* of genetic manipulation in forestry are unconcerned for the environmental impacts of the technology. Even though biotechnology applications to forestry have some undesirable environmental footprints, the advantages of the technology may overweigh the negative impacts (Morris et al. 1999). In addition to economic and financial benefits, (FAO, 2004), biotechnology in forestry can be used to achieve several environmental outputs that can improve the environment. These would include modifications to allow trees to grow in previously unsuitable areas, such as arid and degraded lands, where the trees could both provide restoration benefits to the lands, as well as traditional ecosystem services, such as erosion control and watershed protection. *Supporters* of genetic modification to forestry further argue that the technology provides the potential to restore species severely damaged by pests and disease; mitigate the build-up of atmospheric greenhouse gases including carbon believed to be the causes of anticipated global warming (IPCC, 2001). Genetic engineering applied to forestry possibly assists in augmenting the carbon sequestration capacity of forests and thereby deliver supplementary carbon mitigation options.

Respondents in this cluster have higher mean values for attitudes towards science and research. People's attitude has a positive and significant role in accepting or denying the application of biotechnology in forestry and food production. In many choice experiment studies, those who have higher mean values of the questions related with attitude towards science are always in favour of the application of the technology. For instance, in Canada, there was a strong positive correlation between belief in the promise of science and technology (Jon, 2010). Individuals who hold a strong belief in the promise or benefits of science and technology were significantly less likely to hold strong reservations about science and technology, and vice versa. These individuals have a vital trust in science and the tendency to support genetic modification technology and the resultant production.

The levels of trust in federal and provincial governments have greater mean values in this cluster that can reveal that *supporters* of the application of genetic modification breeding system to poplar trees have strong convictions that the government can formulate and enforce various rules and regulations associated with the technology; and also control if there are some potential negative residuals linked with the application of the technology. Therefore, it is appropriate here to highlight the importance of public's trusts in various stakeholders whether to support or against genetically improved poplar tree for biofuel production. (Hossain et al. 2003; Onyango, et al. 2004) trust in government can be considered as one of the important determinants of public opinions towards genetic modification.

Trust in scientists is also one of important clustering factors with higher mean values in Cluster 4. This shows that *supporters* of the policy which aims at planting genetically improved poplar trees on public land for biofuel production rely on scientists. Trust in scientists can have various dimensions including confidence in what scientists are doing and accepting information that they are promoting. Harvey

(2006) suggested that trust in scientists has important effects on public support for biotechnology; trust is shown to be more important than perceptions of risks or benefits alone. Therefore, when people have more trust in scientists, the likelihood of supporting the application of biotechnology to forestry will be high.

About 37% of members of this cluster reside in Saskatchewan. This indicates that most of Saskatchewanians are *supporters* of planting genetically improved poplar trees. Manitobans have the smallest proportion of members of this cluster. In addition to the aforementioned variables that make people in favour of biotechnology, availability and accessibility of information in relation to the technology plays a significant role. According to a study by the Pew Research Centre in 2010, Saskatchewan is recognized as one of the world's leading ag-biotech research centres. About 30% of the Canadian ag-biotech industry is located in Saskatchewan. Saskatchewan researchers created the world's first genetically modified commercial canola variety and the first genetically engineered animal vaccine. Residents of Saskatchewan access news and information from various sources regarding genetic modification at increasing rate. Hamstra (2007) claims that better informed people are those more likely to see the benefits of biotechnology and supportive of the technology; given that credibility of sources of information about genetic modification is important determinant for public responses. Consequently, the availability of information to Saskatchewanians and the high levels of respondents from this province in the cluster can be the factors that make Cluster 4 members in favour of planting genetically improved poplar tree on public land for biofuel production.

This cluster has the highest proportion of respondents with high-school education level and percentage of young age group; and it has the lowest percentage (13.8%) of respondents with old age distributions. This can imply that younger and middle age respondents are *supporters* of planting genetically improved poplar trees for biofuel production relative to older aged group. This result contradicts with research by Veeman et al. (2005) who measured Canadians concern for genetically modified animal feeds and found that age had a statistically insignificant effect on expressing concerns for biotechnology.

There are important associations between the different stages of an individual's attitudes and socio-economic and demographic attributes such as gender, age, ethnicity, residence and income level, which are found to be directly and indirectly correlated with individuals' attitudes towards biotechnology application in forestry and foods. This relation is supported by Costa-Font et al. (2005), Hossain et al. (2002; 2003), and Veeman et al. (2005) using many econometric techniques including logit and probit models. Siegrist (2000), through causal models, relates opinion differences between males and females with benefit perceptions of biotechnology. These studies consistently found that females perceive lower benefits and the probability of accepting genetic modification is lower than males do. On the other hand, Frewer et al. (2011) suggested that there are statistically insignificant attitudinal differences between male and female respondents with regards to environmental concerns. The number of females in Cluster 4 is higher; hence, it is impossible to conclude that females are always against genetically modified foods and plants as it is suggested by various public perceptions studies towards biotechnology.

Furthermore, Hossain et al. (2012), show that those who live in urban areas are more concerned with genetic modification. Gregory et al (2001) suggested that public's opinions towards the application of genetic modification are not affected by economic, demographic and topographical variables. In contrast, Huang et al. (2006) concluded that factors associated with income of individuals have significant effects on people acceptance of biotechnology than other demographic and topographic variables. The number of urban residents is greater than their rural counterparts; subsequently, one could argue that the spatial distribution of respondents has insignificant impacts on the acceptance level of the application of biotechnology to forestry.

The number of respondents who are engaged in non-farming activities is higher than those in farming activities. The percentages of British Columbians and Manitobans are lower than the percentage of Albertans in Cluster 4 which could reflect that Albertans are relatively more in favour of planting genetically improved poplar tree on public land for biofuel production than residents in these other two provinces.

4.5 Results of Econometric Model Estimation

Usually, institutions which apply biotechnology, are considering the general public preferences for the application of biotechnology to foods and plants. This principle will, of course, affect the public's choices, specifically in relation to single-person choice behaviours. Thus, public preferences should be modelled in such a way that takes preference heterogeneity for any proposed biotechnology introductions into account. Many researchers examined public preferences towards biotechnology application to foods and seeds and suggested and applied numerous modelling methods (Frewer et al. 2011). Much of this research has considered the assumption that individuals have the same preference patters (i.e. only one type of preference). However, in reality there are possibilities for public preferences for biotechnology to be heterogeneous. Indeed the results from the cluster analysis suggest that this is the case. Therefore, in this research, individuals' preference heterogeneity is identified; and the potential causes of this variation are examined.

Table 6: A description of dependent and independent variables (out of the table

Variable Name	Descriptions	
Dependent Variable:		
Vote	*1 if respondent in cluster 'c' chooses the new policy*	
	0 if respondent in cluster 'c' chooses the current policy	
Independent Variables:		
Traditional breeding (TB)	*1 if respondent in cluster 'c' chooses TB*	*0 else*
DNA breeding (DNA)	*1 if respondent in cluster 'c' chooses DNA breeding*	*0 else*
Genetic modification (GE)	*1 if respondent in cluster 'c' chooses GE breeding*	*0 else*
Biofuel production (BF)	*1 if respondent in cluster 'c' chooses BF*	*0 else*

All variables will be represented by the symbols in parenthesis in the subsequent discussions

In order to address the preference heterogeneity of planting genetically improved poplar tree, cluster analysis with binary probit regression model are utilized where respondents' votes i.e. 1 = in favor of the new policy, and 0 = otherwise (in a specific cluster) are considered as the dependent variable; and DNA breeding, genetic modification and biofuel production as independent (explanatory variables) by assuming traditional breeding methods with no biofuel production as the base scenario (i.e. the current policy option).

4.6 Model Results

One of the specific objectives of this study is to measure the extent or likelihood that segments of the public support or oppose the application of genetic modification to forestry. We study this in-depth by defining groups of respondents who have similar attitudes towards planting genetically modified poplar trees on public land for biofuel production using cluster analysis and then within each cluster estimate a probit model on their voting behaviour. By applying probit models within each cluster we argue that preference heterogeneity is similar among the individuals within each cluster (William, 2004).

The probit models generate coefficients which are shown in Appendix X and marginal effects associated with the explanatory variables are shown in Table 7. The marginal effects portray the likelihood of an individual to support or oppose the new proposed policies (i.e. DNA breeding, genetic modification and biofuel production) relative to the current policy (i.e. traditional breeding without biofuel production) are generated. As shown in Table 7, the marginal effects in the *somewhat supporters* cluster have the expected signs which are compatible with the preference patterns of respondents; where members of this cluster have positive opinions for traditional breeding relative to DNA breeding and genetic modification. Conversely, members of this cluster have positive preferences relating to biofuel production relative to the base scenario. Moreover, the marginal effects are significant at 5% and 10% level of significance.

Table 7: A summary of marginal effects from probit models in each cluster

Variables	*Somewhat supporters*	*Somewhat opponents*	*Opponents*	*Supporters*
DNA breeding	- 0.032**	0.017**	-0.036**	0.004**
Genetic modification	- 0.016*	- 0.061*	-0.051**	0.027**
Biofuel production	0.342*	0.384*	-0.275**	0.293*
Traditional breeding***				

** & ** denote significance at or above the 95% and 90% confidence level, respectively*

**** denotes Traditional breeding without biofuel production is considered as the base scenario*

The marginal effects show that when the technology employs DNA breeding, the members of the *somewhat supporters* cluster are less likely to choose the new policy; i.e. the probability of voting for it declines by 0.032. Employing genetic modification technologies seem less impactful, as the marginal effect associated with that policy choice is -0.016. However, if any new policy employing biotechnology is used to produce biofuels, the probability of respondents in the *somewhat supporters* cluster voting for this new policy increases by 0.324.

Members of the *somewhat supporters* cluster have higher preferences for when the technology employs genetic modification than DNA breeding. The preference heterogeneity for the different policy alternatives among members of *somewhat supports* could arise from the socio-economic and demographic characteristics of the members. Respondents in this cluster have higher mean values of knowledge of biotechnology (see Table 3), thus; this variable can suggest respondents are more likely to ask about the impacts of the technology (e.g. Sholdere, 2003) and tend to reject applications of biotechnology.

The highest percentage of young aged groups is found in this cluster and this could impact the likelihood of voting for genetic modification; for example, Ferdaus et al. (2002) claims that young consumers (aged less than 35 years) are more reluctant to choose genetically modified foods. Trust in government, scientists and industries has substantial effects on the acceptance of genetically improved plants, seeds and foods as it is evidenced by many empirical studies. Hence, the lowest magnitude of trust in federal and provincial governments of the members of *somewhat supporters* could imply that there is the likelihood for respondents who show hesitation about biotechnology based on their lower levels of trust in federal and provincial governments not to vote for genetically improved poplar trees. This perhaps might be fueled by the public's perception that the government might not formulate and implement appropriate rules and regulations that minimize the potential negative impacts of biotechnology applications on environmental and human health.

The marginal effects reveal that when the new poplar breeding method employs DNA breeding, the members of the *somewhat opponents* cluster are more likely to vote for the new policy (i.e. the likelihood of voting for it increases by 0.1685). Employing genetic modification has lower impacts on voting as the marginal effect related with the policy choice is -0.061, revealing that the probability of voting for it decreases by 0.061. Conversely, if the new forest management strategies applying biotechnology is used to produce biofuels, the likelihood of members of *somewhat opponents* cluster voting for the new forest policy increases by 0.382.

The negative opinion towards genetic modification relative to the current policy scenario by members of the *somewhat opponents* might be because of high levels of environmentalism of the members of this cluster. According to Fernandez et al. (2006), individuals who are more concerned about applications of biotechnology to foods and crops and its impact on ecosystems argue that more research and development related with crops and non-GM foods should be done by reducing funds for genetic modification. Peelle (2000) suggests that individuals with environmental attitudes are generally interested and sometimes keen about the applications of biotechnology. Most of them have numerous questions and actively search for more information associated with expected environmental, sustainability and global warming impacts, and net benefit evaluation of the application of genetic modification. Thus, if members of the *somewhat opponents* cluster get more information about the potential effects of biotechnology, they could change their preference patterns positively towards the technology and tend to become to supporters of the biotechnology. Finally, if the new policy applying biotechnology to forestry is accompanied by biofuel production, the probability of members of the *somewhat opponents* cluster voting for the new policy increases by 0.384.

In the *opponents'* cluster, all variables are statistically significant and the signs are compatible with the identity of respondents in which these segments of respondents are in favour of the current policy (i.e. opponents of the new forest management strategies). The marginal effects show that when the technology applies DNA breeding, members of the *opponents* cluster are less likely to choose new policy alternatives; in which the probability of voting for it decreases by 0.036. Applying genetic modification appears to be less effective, as the marginal effect associated with the technology is -0.05. Furthermore, if the new policy employing biotechnology to forest policy is used to produce biofuels, the probability of respondents in the *opponents* cluster voting for the new policy declines by 0.275.

The main reasons for having negative voting tendencies for genetically improved poplar trees by members of the *opponents* cluster could derive from lack of trust in scientists, forest industries, provincial and federal government. The opponents of genetically engineered trees argue that significant uncertainties and a wide range of ecological impacts of the trees require thorough and immediate engagement of civil society and governments (e.g. Snow et al. 2005); however, members of this cluster have lower values of trust in government (see Table 3) which likely indicate that the government should strive to combat the negative impacts of genetically improved trees through various regulatory frameworks. Curtis et al. (2004) claim that trust in government regulators concerning adequate safety of the food supply and positive attitudes towards science play an important roles in people's voting (accepting) levels of genetically modified foods and plants. In addition, they claim that there are unanswered questions associated with the prospective long-term effects on human and animal health, and the environment.

All marginal effects, as in the other clusters, are significant and compatible with the preference patterns of the members of the *supporters* cluster. The marginal effect of DNA breeding shows that if the newly proposed policy employs this breeding method, the probability of respondents to vote the new policy will be increased by 0.004. The marginal effect of genetic modification implies that applying genetic modification technologies seems more impactful in which the probability of voting the new forest policy by *supporters* of planting genetically improved increases by 0.03. Finally, the marginal effect of biofuel shows that if the new forest policy applying biotechnology is used to produce biofuels, the likelihood of members of supporters cluster voting in favour the new forest policy increases by 0.293.

Members of the *supporters* cluster are characterized by having lower attitudes towards the environment; and they have higher levels of trust in federal and provincial governments and scientists. In addition, members of this cluster are likely to be in the young and middle age groups. These characteristics could be the main causes that drive the preferences of the members of this cluster to vote in favor of the application of biotechnology to forestry. The lowest score of environmentalism attitude by the *supporter* group does not mean that individuals are unconcerned about the potential impacts of the applications of genetically improved poplar trees on the environment. For example, according to Richard et al. (2002) advocates of genetically improved trees believe that these trees offer new means of improving the forest environment. In addition, supporters of biotechnology applied to crops have a conviction that if the effects of genetically modified plants are properly tested for both risks and benefits to humans and the environment, transgenic crops are more likely to increase agricultural biodiversity and help maintain native biodiversity rather than to endanger it. Furthermore, Darryl (2000) claims that the proponents of biotechnology suggest that a substantial reduction of environmental pollution could occur as the enhancements of the technologies are increased.

The degree of trust in regulatory bodies has played a significant role in the publics' attitudes of accepting the application of the technologies; for example, Tait (2007) uncovered that without trust in key actors of biotechnology, people may misperceive the risks and uncertainties and be influenced by exaggerated claims of those opposing the technology. Thus, trusting experts and governments has long been considered one of the important factors to reduce the public's scepticism towards biotechnology applications. Optimists of the application of biotechnology to foods and plants argue that the government is able to regulate, strengthen and rationalize procedures to ensure that the environment and public health are protected and that the benefits and risks of the technology are predictable and science-based (FAO, 2004).

Supporters of planting genetically improved poplar tree on public land for biofuel production have the lowest scores relating to knowledge about biotechnology and forest operations. This contradicts research results by Gaskell et al. (2009) who suggest that knowledge is an important determinant of support for science and technology. Therefore, the likelihood of voting in support of genetically modified foods and plants will be high when the public has more knowledge and information associated with the technology.

5. Conclusion

It is natural that individuals differ in their tastes and preferences for new products and technologies. One individual might be eagerly interested about the new products and technologies; a second individual could show cautious interest, while a third individual completely rejects the technology. Individuals can be clustered according to these preferences for a new technology. The clustering procedures can be based on some underlining factors in which individuals have similar preferences (Rogers, 2003). In this study we assume these factors to be attitudes which are associated with various situations that could capture individuals' preference towards genetically modified poplar trees.

The study reveals that overall preferences for planting genetically improved poplar trees on public land in western Canada vary significantly across the sample. Respondents hold different preferences for genetically improved poplar trees due to numerous factors; such as environmental engagement, trust in scientists and governments, and knowledge of biotechnology. However, through cluster analysis, the study has formed clusters of individuals who have similar attitudes and we assume have similar preferences (i.e. within clusters) for planting genetically improved poplar trees. This approach is used to categorize individuals who hold significantly similar preferences into one cluster; and to identify the underlining factors that potentially drive their preferences.

The use of subgroups defined by their attitudinal and socio-demographic characteristics is very important in the formulation of public policy which considers the full set of individuals' interests and their different groupings. The approach provides information about how public preferences could be incorporated into policy decisions in a way that respects both the multi-criterial nature of those decisions, and the heterogeneity of the population in relation to the importance assigned to relevant criteria (Robin et al. 2015).

Therefore, the overall objective of this research was to employ a respondent clustering approach that would parsimoniously uncover clusters of voters that share similar preferences towards a policy of planting genetically improved poplar trees on public land in western Canada; and to discover the likelihood of voting this policy by members of each cluster. Through use of cluster analysis combined with probit models; we gained understanding of how Western Canadians' differ in preferences for forest policy changes.

The study has identified and characterised four clusters of western Canadians concerning their perceptions and preferences for planting genetically improved poplar trees on public land for biofuel production using twostep clustering technique by Garson (2010). The four distinct clusters are *somewhat opponents*, *somewhat supporters*, *opponents* and *supporters* of genetically improved poplar trees.

The cluster analysis has used a number of factors to form clusters of individuals who likely have similar preferences for biotechnology and forest policy linkages. These factors include the level of education, knowledge of respondents and trust in scientist and governments. Due to these and other demographic factors, preferences are heterogeneous across clusters of respondents. Therefore, specifically designed strategies need to be implemented by the appropriate authorities in promoting and implementing the policy of planting genetically improved poplar trees.

Here, it could be very important to examine preference heterogeneity among opponents and supporters of the new policy in order to identify the variables that made *opponent* respondents not support biotechnology policy options relative to the *supporting* groups. *Opponents* have higher values for New Ecological Paradigm psychometric scale indicating that they are relatively more in support of environmentalism than their counterparts. Benbrook, (2012) suggests that opponents of biotechnology claim that the scientific knowledge about potential risks and benefits of the technology on environment is undeveloped and little understood. Potential net gains in agricultural productivity and the potential for higher profits are both uncertain; thus, the potential for higher damaging impacts of introducing genetically modified products are unknown. This leads to calls for a moratorium to be placed on these products until more information is available. Therefore, any new proposed forest policy should focus on various ways that enable reductions in the subsequent negative impacts associated with the application of these technologies on the environment.

Furthermore, members in the *opponent* group have higher values of knowledge of biotechnology and forest operations, indicating that members of this cluster answered *correctly* to the knowledge questions related to biotechnology. This contradicts a research result by Finegold et al. (2004) which uncovered knowledge as an important determinant in support for introducing biotechnology - the more people are informed, the more likely they are to be supportive of the technology. On the other hand, *supporters* have higher levels of trust in scientists, forest industries, federal and provincial governments, attitudes towards science and research and environmental non-governmental organisations (ENGOs). It could be easily understood that the preferences of *opponents* of biotechnology and ENGOs have similar patterns in which both of them are against the application of the technology (e.g. Maxwell et al. 2007); however, in this study *supporters* have higher levels of trust in ENGOs.

Harvey et al. (2002) shows that the confidence of people in government has been an important factor associated with consumer acceptance of genetically modified foods. In addition, Lewin (1943) suggests that the best way to increase the acceptance of biotechnology is to decrease the perceived risk in which the government is to play an important role since it is in charge of enforcing associated regulations. Gaskell et al. (2010) found that the lack of trust in organizations such as scientists and the federal government with the greatest resources and responsibilities for ensuring the safety of genetically improved foods and plants should be seen as an important obstacle to the adoption of biotechnology. It is more likely that the public's trust in various organisations that promote the application of biotechnology is the most important variable that any new forest policy should consider before its applicability. Therefore, it is recommended that the new policy should suggest the ways how its promoters enhance the public's trust in them. For example, Siegrist, (2000) suggests that organisations should improve their relationships, structures and competences to answer the challenges of the use of new technologies to individual citizens and society. This service to develop public trust and increases the acceptability of the technology.

It is also recommended that the availability and provision of genuine information associated with biotechnology, specifically genetically improved poplar trees, is an important factor for public acceptance of newly proposed policy. As mentioned earlier, Saskatchewanians seem more likely to accept genetically improved poplar trees due to being more informed about the technologies. Hence, the promoters of the new policy should communicate its importance for forestry through improvement of wood quality, production, insect resistance and faster growth rates of improved poplar trees. These promoters could design and provide accurate information and educational programs that increase respondents' acceptance levels of biotechnology according to the specific preference patterns of members of each cluster. As an example, Jon (2004) suggests that organized and oriented information to stimulate the public's aspirations is an important element to induce changes in behaviour.

The lower mean value of attitude towards science and research in opponents segments could impede the successful application of the new policy. For example, Hoban, (1997) claims that negative attitudes towards biotechnology in food, health and medicine generate significant obstacles for the application of the technology when people tend to associate genetically modified products with commercial objectives. However, Fernandez et al. (2006) suggest that compared to foods crops, opponents of biotechnology usually seem to hold positive attitudes towards genetically modified biofuel crops, and that they readily associate such crops with the forthcoming fuel crisis and the need to combat global warming (environmental objectives). Therefore, it is recommended that the new policy should focus on the reduction of the potential environmental impacts of genetically improved poplar trees through various mechanisms.

The source of information also plays an important role in affecting the preference of individuals towards biotechnology applications in forestry. Frewer (1995) suggests that it is mostly known that provision of genuine information is expected to influence attitudes; although the social background in which the information is disseminated is also important to determine public reactions to that information. This, therefore, suggests that there should be credible, trusted and regulated information sources provided in order to enhance acceptability of genetically improved poplar trees.

The extent of regulations which slowdown the application of biotechnology have been influenced by the combination of self-interested benefit maximization and rent seeking behaviours of several interest groups involved in the policy-making procedures. This in turn has a negative impact on the economy of a given country by increasing the forgone benefits that would have been gained from the application of the technology (Graff et al. 2009). Therefore, understanding the preference heterogeneity of various segments of individuals associated with biotechnology has tremendous advantages to obtain strong evidences which could facilitate the application of the technology to encourage the Canadian forest sector.

To conclude, the newly proposed policy of planting genetically improved poplar trees on public land should consider the heterogeneity of preferences among different age groups, genders, occupation, location and educational levels before implementing any new technologies in provincial forest operations on public land. This can only occur through the provision accurate and unbiased information that could enhance the public's awareness about "exotic" trees.

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Appendix 1

A summary of coefficients from probit regression in each cluster

Clusters	Variables	Coefficients	Z	P-value
Somewhat supporters	DNA breeding	- 0.092813**	1.82	0.069
	Genetic modification	- 0.18429*	- 3.6	0.000
	Biofuel production	1.003241*	12.18	0.000
	Constant	- 0.7432561*	- 11.08	0.000
	Wald chi2(3) = 418.19 Prob > chi2 = 0.0000 Log likelihood = -3363.0877 Likelihood-ratio test of rho=0: chibar2(01) = 2016.00 Prob >= chibar2 = 0.000			
Somewhat opponents	DNA breeding	0.049949	0.98	0.325
	Genetic modification	- 0.18003*	- 3.55	0.000
	Biofuel production	1.137304*	24.95	0.000
	Constant	- 0.61687*	- 9.64	0.000
	Wald chi2(3) = 545.36 Prob > chi2 = 0.0000 Log likelihood = -3340.7798 Likelihood-ratio test of rho=0: chibar2(01) = 1782.23 Prob >= chibar2 = 0.000			
Opponents	DNA breeding	- 0.10879**	- 1.71	0.044
	Genetic modification	- 0.15262**	- 1.83	0.068
	Biofuel production	-0.835262**	1.68	0.000
	Constant	- 0.83049*	- 7.18	0.000
	Wald chi2(3) = 110.77 Prob > chi2 = 0.0000 Log likelihood = -1297.8615 Likelihood-ratio test of rho=0: chibar2(01) = 956.83 Prob >= chibar2 = 0.000			
Supporters	DNA breeding	0.01098**	1.82	0.035
	Genetic modification	0.07224**	1.72	0.043
	Biofuel production	0.794651*	16.88	0.00
	Constant	-0.41956*	6.04	0.00
	Wald chi2(3) = 247.50 Prob > chi2 = 0.0000 Log likelihood = -2823.3574 Likelihood-ratio test of rho=0: chibar2(01) = 1561.26 Prob >= chibar2 = 0.000			

*&** denote the variable is significant at 1% and 5% level of significance