Climate Change, Forests, and Communities:
Identifying the Range of Acceptable Human Interventions in Forested Ecosystems

by

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Abstract

Forest management is presently undergoing major changes to adapt to a changing climate. The objective of this research is to examine the variation in perceived acceptability of potential forest management interventions that can mitigate the risks of climate change among rural forest-based communities in British Columbia (BC) and Alberta. Engaging communities that will be impacted by such changes allows for the formation of forest policy that benefits local users. To accomplish this, four communities were selected for case studies and a mixed method research design was employed. Three management scenarios were designed to represent a spectrum of human intervention in forested ecosystems: continuing the status quo of planting local selectively bred seed; implementing assisted migration of tree populations by utilizing genomic and climatic knowledge; and genetically engineering trees to grow well in a changing climate. Three qualitative focus groups were conducted in each community and an exit Q sort exercise was administered to measure the perceived acceptance of a set of nine forest adaptation management scenarios. In tandem, a survey was administered that collected attitudinal data on social and political issues that were used to identify participants’ cultural worldviews. This data was used to determine if the theory of cultural cognition of risk (CCR) shaped the way participants perceived adaptation strategies.

Results indicate that forester participants perceived the assisted migration-based strategies as relatively less acceptable compared to the other social groups. Environmentalist participants prioritized adaptation strategies that featured mixed species and business participants perceived all of the adaptation strategies more neutrally. Cultural cognition of risk was determined to play a role in shaping perceptions of the adaptation strategies in that those who were classified as individualists were most likely to perceive the local-based strategies as
acceptable and least likely to perceive the assisted migration-based strategies as acceptable. Conversely, hierarchist participants were more likely to perceive assisted migration-based strategies as acceptable than the other cultural groups. In studying the perceptions of forest-dependent community residents, delivery of forestry-related climate change adaptation policy can be tailored to address the concerns and issues that these communities face.
Preface

This study was designed and written by Molly Moshofsky under the supervision of Dr. Rob Kozak. The research questions were identified by Molly and approved by her supervisor Dr. Rob Kozak and committee members Dr. Debra Davidson and Dr. Mike Meitner. Dr. Debra Davidson provided guidance on risk perception theories employed in the study. Additionally, as this study was funded by the Genome BC and Genome Canada AdapTree project, the research design incorporated guidance provided by the AdapTree team led by Dr. Sally Aitken.

Development of ecosystem visualizations administered during some of the focus groups was contracted to Dave Flanders. Assistance in administering BC focus groups was given by Phil Grace MSc. and Alberta focus group assistance was provided by an undergraduate field assistant, Mélia Lagacé. Analysis of the data from this study was completed by Molly Moshofsky. A portion of the results were published in the University of British Columbia, Faculty of Forestry’s newsletter, Branchlines (Moshofsky, M. M. (2013, April) as “Perceptions of Climate Change Adaptation”, Branchlines 24(1):12-13).

This research was approved by the UBC Behavioural Research Ethics Board (Certificate Number H12-02034).
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List of Abbreviations

AAC: Allowable Annual Cut
AM: Assisted Migration
BC: British Columbia
BEC: Biogeoclimatic Ecosystem Classification
Bt: Bacillus thuringiensis
CCR: Cultural Cognition of Risk
FD: Forest Dependence
FMA: Forest Management Area
GDP: Gross Domestic Product
GIS: Geographic Information Systems
GM: Genetic Modification
GMO: Genetically Modified Organisms
ha: Hectares
IPCC: Intergovernmental Panel on Climate Change
m³: cubic metres
MPB: Mountain Pine Beetle
Mt: Megatons
ppm: Parts Per Million
RPF: Registered Professional Forester
spp: Species (plural)
TSA: Timber Supply Area
US: United States
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Chapter 1  Introduction

Forests have a diverse set of roles related to the provision of ecosystem services, including water purification, cultural benefits that are highly valued, the provision of timber products, and other economic resources that contribute significantly to Canada’s gross domestic product (GDP) and labour force. However, climate change alters this critical social-ecological system’s ability to provide these services, values, and resources. Trees are adapted to the local climates in which they grow, and populations have naturally adapted to historic climate shifts (e.g. post glaciation) through unique seed dispersal methods. However, the present climatic shift taking place is occurring at a rate that exceeds all past observable natural migration events and Aitken et al. (2008) conclude that many tree populations will become maladapted to their local growing environments. The impetus to adapt the worlds’ forests to changing climates has resulted in a number of innovative adaptation strategies that challenge the foundations of traditional forest management. Specifically, significant advances in the field of genomics now allow researchers to identify networks of genes that produce the most robust phenotypes for specific environmental conditions (Sork et al., 2013), which significantly reduces the time required to select and breed trees for commercial replanting.

Presently, research is being conducted on the plausibility of implementing assisted migration informed by genomic and climatic analysis of lodgepole pine (Pinus contorta) and interior spruce (Picea spp.) within the provinces of British Columbia (BC) and Alberta as a way to adapt commercially managed forests to shifting climates. Given the controversial nature of moving seed outside its natural region and the use of genomics to inform seed selection, policy makers, and geneticists wish to gain an understanding of the perceived acceptability for the project.
With an interest in the nuances in perceived acceptability of various aspects of adaptive forest management, a selection of management scenarios was created that highlighted different forms of human interventions that could take place on the landscape in the coming years. Two research questions emerged that explore the limits of perceived acceptability regarding potential adaptive forest management techniques:

1. How does perceived acceptability of a range of forest management climate change adaptation strategies and outcomes vary among forest-dependent community members?

2. Can the cultural cognition of risk theory be used to better explain variation in public perception towards these forest management climate change adaptation strategies?

Mixed method focus groups were conducted within four forest dependent communities BC and Alberta to answer these questions. Perceptions were elicited from foresters, environmentalists, and the business community in each of the case study communities to facilitate comparable datasets across the study. Foresters were selected as a social group for study because these individuals will be directly utilizing management techniques. Individuals active in the environmental community were selected as a social group of interest for the study because of their vested interest in how natural ecosystems are managed. Lastly, the business community was consulted to gain an idea of how individuals that do not necessarily possess specialized knowledge in forest management perceive these novel techniques. Through this study, it was hoped that a deeper understanding of how people respond to the risks of applied climate change adaptation could be discerned.
Chapter 2  Literature Review

In order to fully understand the mechanisms informing perceived acceptability amongst forest dependent community members, a literature review was conducted on several topics. Section 2.1 provides an overview of the latest research on climate change and its projected effects on Western Canada’s forests. Section 2.2 compiles the contextual information on the relationship between forestry and rural communities in Western Canada. Sections 2.3 discusses the latest research on climate change adaptation options in forestry, highlighting genomic applications and assisted migration, respectively. Section 2.4 provides an overview of the evolution of risk perception theory. Lastly, Section 2.5 describes the study research objectives that emerged.

2.1 Climate Change

Carbon dioxide, a compound historically present in the atmosphere at a concentration of 280 parts per million (ppm) (Vitousek, 1997), has increased to 398 ppm in the last 210 years (Scripps Institute of Oceanography, 2014). As greenhouse gas emissions (e.g. carbon dioxide, methane, nitrous oxide) continue to accumulate in the atmosphere, the climate is changing. Indeed, the latest report published by the Intergovernmental Panel on Climate Change (IPCC) (2013) states that the global surface temperature has increased 0.85 degrees Celsius between 1880 and 2012. With regard to future climate change, the Pacific Climate Impacts Consortium (2014) projects an average increase of 1.7-4.5 degrees Celsius across BC by 2080. While in Alberta, mean annual temperature “is expected to rise 3-5 degrees Celsius” by 2050 (Cerezke, 2009, p. ii). These numbers have significant implications for Western Canada’s forests as tree populations whose genetics have incorporated thousands of years of adaptations to their local
regions will be maladapted to the sudden change in climate. Such maladaptation makes forests more vulnerable to pest and disease outbreaks. Moreover, as is presently the case with the mountain pine beetle outbreak, large tracts of dead and dying trees increase the danger of large-scale wildfire. For instance, Figure 2-1 shows the projected changes in the distribution of BC’s biogeoclimatic ecosystem classification (BEC) zones and illustrates the large-scale reductions in some habitats, as well as the large-scale increases in others that are expected to occur (Wang et al., 2012).

![Figure 2-1: Wang et al.’s (2012) projected BEC zone distributional shifts that are expected to occur as a result of climate change in BC. From left to right, the maps represent the 2020s, the 2050s, and the 2080s.](image)

In addition to endangering the commercial timber supply, there is also a feedback mechanism between trees and further climate change. Specifically, as trees grow, they absorb carbon dioxide from the atmosphere and store it in their biomass. During the 1990s, BC forests were absorbing 100 megatons (Mt) of carbon from the atmosphere per annum and emitting approximately 80 Mt back, making them a net sink for carbon storage. However, with increased occurrence of forest fires and the beetle outbreak killing a significant number of trees, the sequestration rate has decreased to approximately 35 Mt per annum, while the release rate has only increased from 1990 levels (BC Ministry of Forests Mines & Lands, 2010); an imbalance, which has transformed the province’s forestland into a net source of carbon. The forestland in
western Alberta was also affected by MPB-related die back of pine stands, impeding carbon sequestration for the province. However, the natural disturbance in Alberta that is projected to have the most significant impact on the province’s carbon balance is fire. Fire is a naturally occurring disturbance on the landscape, but as the climate becomes more arid, Alberta’s forest fires are projected to become 40-50% more severe (Cerezke, 2009). Finally, vulnerability to pest outbreaks is only projected to increase with climate change, making this a serious concern for the forested provinces of Canada and other northern latitude forested countries that are already struggling to reduce their greenhouse emissions. In seeking ways to better equip the jurisdictions with rapidly changing forests, policy-makers must consider adaptation strategies carefully, for they all entail a large-scale human intervention in the ecosystem.

2.2 Forestry and Communities

2.2.1 British Columbia

Forests cover 95 million hectares (ha), or 60% of BC, 95% of which is publicly owned (BC Ministry of Forests Mines & Lands, 2010). This extensive forest resource-base has long supported rural communities across the province and presently is the driving industry for 40% of BC’s regional economies (Council of Forest Industries, 2014). The present distribution of forest-dependent communities in BC can be traced back to the post-World War II era when W.A.C. Bennett, Social Credit Premier of BC, invested heavily in rural development to feed the booming post-war US economy. Long-term corporate tenure holders supported these communities. Tenure holders during this period of Fordist expansion were required, through the appurtenancy clause, to process timber in the region of harvest (Young & Matthews, 2007). This resulted in numerous mills that were geographically distributed over the province. Additionally, resource companies were encouraged to invest in infrastructure for the new towns, supporting the
province’s simultaneous goals of settlement and resource extraction (Young & Matthews, 2007). Rural communities prospered under booming employment opportunities and the export relationship with the United States strengthened. However, this was an unsustainable model economically and environmentally because, for the mills to run, there had to be a steady flow of timber, so often times, over-cutting took place to ensure these conditions (Hayter, 2000).

Trees are a renewable resource; however, proper management is required to ensure that they are being extracted at a sustainable rate. This includes maintaining a harvest volume that balances the regeneration rate. However, in BC, timber harvest volumes have markedly increased throughout the 20th century, peaking at 90 million cubic metres extracted in 1987 and again in 2005 (BC Ministry of Forests Mines & Lands, 2010, p. 136). Figure 2-2, shows that harvesting occurred at a rate that far exceeded that of reforestation during the peak harvest levels realized in the 1980s. Concern mounted over the amount of understocked forestlands that continued to fragment the BC landscape. In order to regain an equilibrium between removal and regrowth, the Ministry of Forests began requiring post-harvest replanting to be performed by forest-tenure holders, which was an effective way of addressing the deficit of regeneration (BC Ministry of Forests Mines & Lands, 2010; Ying & Yanchuk, 2006).
Figure 2-2: The magnitude of disturbances (human-induced and natural) relative to the reforestation from 1970-2006 in BC (BC Ministry of Forests Mines & Lands, 2010).

Pressures from importers of BC wood products led to the incorporation of market-based reforms in 2004 to increase the competitiveness of the forestry sector. These included eliminating minimum cut control requirements and the associated appurtenancy clause (Macdonald, 2004). This allowed firms to mill logs where labour costs were cheapest. Such restructuring of the sector has had negative impacts on the communities dependent on harvesting and milling for employment. However, pressure to diversify economically has also resulted in increases in tourism and other resource activities in many communities (Schooling & Cumming, 2005). Currently, there remain 48 communities in BC that are economically dependent on forestry and forestry-related employment (Statistics Canada, 2008).

Complicating matters, an outbreak of mountain pine beetle (*Dendroctonus ponderosae*) has swept through the lodgepole pine (*Pinus contorta*) forests that dominate BC’s interior in the
past decade. By 2008, 14.5 million ha of lodgepole pine had been attacked and projections estimate that, by 2015, 70% of the mature individuals growing in BC will have been killed (BC Ministry of Forests Mines & Lands, 2010, p. 11). The mountain pine beetle is endemic to Western Canada. However, cold winter temperatures generally kill off the insects, inhibiting the spread of the outbreak from season to season. An increase in mean winter temperatures in BC attributable to global climate change resulted in an increase in benign winter habitat for the beetle, which allows for infestations to spread year round (Regniere et al., 2003). Short-sighted forest management also exacerbated the magnitude of the outbreak in the sense that maximizing the volume of harvest per unit cost, suppressing wildfires, and replanting vast areas with the fastest growing interior species (lodgepole pine) led to simultaneous maturation. This meant that there was a massive region of trees entering the life stage of increased vulnerability to pests and diseases and, with this setback, there is once again a growing deficit of insufficiently stocked stands (Taylor & Carroll, 2003).

Despite all of these challenges, the forest industry remains a relevant component of BC’s economy, representing 3% of the provincial GDP (Council of Forest Industries, 2014). China’s recent economic boom has manifested in a spike in exports of raw logs to the rapidly growing country (Denis, 2013). There has been an increasing trend in raw log exports from BC from 3.8 cubic metres in 2002 to 6.4 cubic metres in 2012, for a total of 46.8 cubic metres exported over the decade (Ministry of Forest Lands & Natural Resource Operations, 2013).

2.2.2 Alberta

Compared to BC’s historical reliance on forests, Alberta has a much different profile of resource use. Though forests cover approximately the same proportion of Alberta as is seen in BC, only 21 communities are dependent on the forest sector economically (Alberta Forest
Products Association, 2014; Statistics Canada, 2012). With its arid prairie landscapes in the south, the interior province first supported its population through agriculture (Alberta Agriculture and Rural Development, 2014). In the 1940s, the oil booms began, carrying Alberta into the 21st century as the wealthiest province in Canada, with a GDP per capita of $80,200 in 2012. Industrial forestry contributes just 1.2% to the provincial GDP (Alberta Canada, 2014; Alberta Forest Products Association, 2014). With such a mosaic of land use activities on the ground, the role of forestry is understandably less significant in the public's eye. However, it still provides 38,000 jobs and $9 billion to the provincial economy, making it the third largest contributor to the provincial economy (Alberta Government, 2014). Reforestation practices in Alberta are strong, with “two to three trees” being planted for every one that is harvested (Alberta Forest Products Association, 2012). The market for Alberta wood products is predominantly international and similar to that of BC in that China and the United States (US) are the two largest importers of Alberta forest products (CBC News, 2014).

The dominant natural disturbance for Alberta boreal forests is wildfire (Tymstra et al., 2007). An average of 867 fires occurred annually between 1961 and 2004. Most of these fires are small and cause minimal damage. However, there is concern over the increasing “frequency of very large, high intensity and high severity wildfires that are expensive, dangerous, and hard to contain” (Tymstra et al., 2007, p. 153). This is exacerbated by the presence of MPB on the landscape. Trees killed from beetle infestations are much drier, making for hotter-burning fuel. Presently, “6 million ha of pine forest” are at risk for MPB infestation (Alberta Government, 2009). Climate projections show only increasingly arid conditions for the province, heightening the risk for large scale, high impact fires.
2.3 Forests and Climate Change Adaptation

As the global population and demand for forest products continues to grow, the pressure to produce timber from the finite land-base will only continue to intensify. This is compounded by changes occurring in our climate. There is a need to explore climate change adaptation options to maintain resilient and healthy forests that support communities and the environment. However, some of the most promising adaptation strategies available are perceived to be controversial by the general public. For a deeper understanding of the concepts that may be perceived as risky to members of forest-dependent communities, the following sections will discuss some of the possible adaptation mechanisms that are presently being considered within a forestry context.

2.3.1 Genomics and Forestry

Genetics is the study of genes, heredity, and variation in living organisms (Griffiths et al., 2000). Genetics has long played a role in the way that tree breeders select trees for planting. Historically, breeding programs focused on selecting trees that display fit and vigorous phenotypes from wild stands and bringing seed back to regional nurseries. Seedlings grown from these seeds are then grown and bred over a series of generations to produce genetically superior genotypes for reforestation (Ministry of Forests Lands & Natural Resource Operations, 2000). Such selective breeding is a lengthy process and requires decades to produce results (Heaman, 1963). However, the results demonstrate that favoured traits can be successfully improved through breeding as shown in Figure 2-3 (Ministry of Forests Lands & Natural Resource Operations, 2000).
Recent advances in technologies have allowed entire genomes to be mapped out. Where a gene is a singular molecular unit, the genome refers to all genes that exist in a species’ genetic makeup. Coding a genome for an organism allows scientists to see the entire genetic blueprint for the species, thus allowing for a more holistic understanding of the interactions between genotypes, phenotypes, and the environment (Sork et al., 2013). This area of study, collectively referred to as genomics, allows for a totally different approach to tree selection. For instance, research is presently being conducted on marker assisted selection which, if accurate, could accelerate the process of tree breeding significantly (Beaulieu et al., 2011). In marker assisted selection, marker genes are identified that could be used to more accurately identify a given phenotype much earlier in the breeding cycle than with conventional tree breeding (SMarTForests, 2012).

The genome sequences of both lodgepole pine (Pinus contorta) and interior spruce (Picea spp.) – two important species in BC and Alberta – have been mapped out (Birol et al., 2013; Reid et al., 2013). In addition, the subfield of landscape genomics that has recently

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**Figure 2-3:** Genetic Gain observed in selectively bred tree seed (Ministry of Forest Lands and Natural Resource Operations, 2000).
evolved allows for scientists to study the relationships between “genotypes, phenotypes and environments” from individual trees sampled across a species range (Sork et al., 2013, p. 902). This, then, shows the phenotypes involved in adaptation to local climatic conditions, which is information that could be used by tree breeders to select individuals that would be best suited for specific climates. Such knowledge is critical to facilitating effective climate change adaptation.

The most contentious application of tree genomics is genetic modification (GM). GM is a method where a gene for a favoured trait is inserted into the genome of an organism (Frankenhuyzen & Beardmore, 2004). Presently, there are several research projects focused on developing GM solutions for forestry problems. For instance, as seen in the case of BC’s mountain pine beetle infestation, pests can have a devastating impact on tree fitness. Inserting genes from the bacteria *Bacillus thuringiensis* (Bt) into poplars (*Populus spp.*) can induce resistance to lepidopteran defoliators and, thus, increase the productivity of the stand, which can increase timber yields and sequestered carbon. Additionally, Wilkerson et al. (2014) show promising progress on producing GM trees that are designed for easier deconstruction. The motivation behind this is that there are a number of uses for certain components of trees that are presently uneconomical to utilize because the process of deconstruction is intensive and engineering trees for this purpose could overcome such barriers.

The first tree species to have its genome mapped was Western balsam poplar (*Populus trichocarpa*) and it has consequently received the most attention from genetic engineering research (Tuskan et al., 2003). However, conifers such as the pines, spruce, and fir that dominate 83% of BC’s landscape possess a more complex genetic make-up than their deciduous counterparts, meaning that progress in genetic engineering is slow (BC Ministry of
Forests Mines & Lands, 2010). However, there has been research done in Canada on an insect resistant transgenic white spruce \textit{(Picea glauca)} (Frankenhuyzen & Beardmore, 2004).

Heightened public perceptions of the risks associated with manipulating genetic structure of organisms (GM) has resulted in only 700 field trials of genetically engineered trees conducted worldwide, only two of which have been conducted in Canada and none in BC (Bonfils, 2006; Frankenhuyzen & Beardmore, 2004; Yanchuk, 2010). A potential source of contention exists in the use of genomics to inform even the less invasive adaptation efforts. Though there is no use of GM technology in most genomic-based adaptation strategies, the term genomics carries a loaded connotation denoting human manipulation of nature (Ausubel et al., 2006; Hall, 2007; Strauss et al., 2009). There are generally low levels of knowledge regarding this technical concept and media coverage has focused primarily on transgenic applications (Pin & Gutteling, 2009), increasing the potential for the public to equate the broad field of genomics to its most controversial form. For instance, activists destroyed 400 seedlings and trees being grown for a tree breeding trial at University of British Columbia (UBC) in 1999, valued at between $200,000 and $300,000. The vandalism took place during a suspected “anti-genetic engineering week”, supporting the notion that public perceptions might be shaped by the most extreme form of genomics that is seen in the media. As one researcher stated, "We're working with best species, which some people may confuse with genetics and stuff like that. But most of it is just picking the best species from an area and making sure that works well and is best for growing in that particular area" (Kines, 1999).

2.3.2 Assisted Migration

Trees are locally adapted to the areas in which they grow. Over successive generations, genotypes that are optimal for a given climate are naturally selected and perpetuated, producing
populations of trees that grow well under the local climate conditions. Early tree breeders in BC discovered that moving seeds outside their naturally adapted region “…may result in maladaptation; e.g., cold injury, drought and susceptibility to disease and insects causing growth loss or mortality” (Ying & Yanchuk, 2006, p. 2). This resulted in the development of regional seed zones that control seed transfer for reforestation so that seed is grown where it can achieve its optimal genetic potential.

This system has been an effective tool for forest managers since the 1940s (Ying & Yanchuk, 2006). However, global climate change challenges conventional seed transfer management. As seen in Figure 2-1, observed and projected shifts in climate zones will result in many tree populations growing in sub-optimal conditions. Evidence shows that the climate is presently shifting at a rate that exceeds forest trees’ adaptive and migratory capacity (Aitken et al., 2008). This increases the risk of pests, disease, drought stress, and wildfire disturbances occurring in forests. In addition to having large-scale impacts on forest-dependent community livelihoods, it would also decrease provincial revenue from forestry. One potential way to mitigate these losses would be to shift from a regionally-based seed transfer system to a climate-based seed transfer system.

In this way, forest managers could facilitate the migration of tree populations – and, in some cases, species – to areas that are expected to have more favourable climate conditions. However, the concept of assisted migration (AM) has been a topic of debate within scientific circles (Aitken et al., 2008; Hagerman et al., 2010; McLachlan et al., 2007). McLachlan et al. (2007) observe that the scientific debate focuses on the potential for “…unintended consequences of well-intentioned human interference” (p. 299) with natural ecosystems. Opponents of assisted migration highlight the risks of the introduced species becoming invasive
and outcompeting resident species, or exposing existing plant or michorrizal communities to new pests or diseases. Invasiveness is less of an issue for the form of assisted migration that would be implemented in Western Canada; however, increased vulnerability to certain pests and disease remains a risk even when only implementing assisted migration of tree populations within a species range (Carroll, *personal communication*, September 4, 2012; Simard, *personal communication*, September 10, 2014).

The risk of unintended consequences in this particular case is also fuelled by scientists’ limited capability to model complex ecological and climatic systems whose behaviours are dependent on human behavior (Aubin et al., 2011). The debate is also contentious because of the projected risks to existing ecosystems of doing nothing to assist adaptation. Given the context of climate change, if adaptation is not pursued, it is expected that trees growing in their historic local ecosystems will become more vulnerable to the risks of pest and disease outbreaks, as well as wildfire (Aitken et al., 2008). The rate at which the climate is changing is forcing those scientists who were once strongly opposed to all forms of assisted migration to reconsider their positions.

In bringing this debate to the public, there is similar potential for controversy. For instance, the more contentious forms of assisted migration and those that have received the most media attention are instances where species have been translocated far distances. There are generally low levels of knowledge regarding assisted migration of tree populations (Aubin et al., 2011) and, thus, a chance that, when confronted with the concept of assisted migration, members of the public might have heightened risk perceptions shaped by the examples that get publicity because of the unintended consequences. For instance, the case of introduced eucalyptus *spp.* in California causes variety of issues for native vegetation because of its luxury
water consumption that lowers the water table and its highly flammable foliage that increases risk of fire. This represents a highly publicized instance of assisted migration where the risks seem to outweigh the benefits (California Invasive Plant Council, 2014; Gross, 2013).

Risk amplification from the public could hinder government sponsored plans for forest adaptation. For such reasons, it is critical to engage the public and particularly residents of forest-dependent communities who will be most affected by these changes to forest management and to identify where possible misconceptions exist, as well as what other risk factors play a role when considering these topics. For instance, core value positions such as those that resist any idea of “tampering with nature” (Sjöberg, 2000) or those who accept *prima facie* “limits to scientific knowledge” (Sjöberg, 2001) will likely play significant roles in shaping public perceptions regarding the proposed changes to forest management. This lends itself to the notion of risk perception, as discussed in the subsequent section.

### 2.4 Evolution of Risk Perception Theory

Theories of risk perception play a crucial role in understanding how the public reacts to new technologies and concepts. Thus, it is relevant to review some of the theories that could contribute to an understanding of the public's perceptions toward proposed adaptation strategies. The classical model of risk perception that has dominated the field is Slovic's (1987) psychometric model, which posits that laypeople's brief affective judgments (fuelled by dread and uncertainty regarding new technologies) form their perceptions of risk because they are not able to measure risk analytically. However, affective reactions only partially explain how people perceive risks.
In seeking other ways to explain risk perception, Douglas and Wildavsky (1983) created the cultural theory of risk perception. Though critiqued for deviating from the traditional paradigm of risk perception that emphasizes individual rational choice, cultural theory of risk perception provides an interesting perspective on how one’s cultural bias informs the way one interprets and characterizes risks (Thompson et al., 1990). Kahan (2012) refined the theory to its present form known as cultural cognition of risk (CCR) where individuals’ political and social worldviews place them within a group (individualist/communitarian) and grid (hierarchy/egalitarianism) framework. Specifically, an individual’s views related to social accountability toward oneself and others can be used to determine their placement on the grid spectrum, with low group scores indicating individualism and high group scores indicating communitarianism. Meanwhile an individual’s beliefs and attitudes about the appropriate role of authority and decision-making structures identifies where they fall on the grid spectrum, with high grid scores indicating strong beliefs in hierarchy and low grid scores indicating belief in egalitarianism (Douglas & Wildavsky, 1983). Taken together, an individual’s placement within the group-grid framework determines their cultural bias as an individualist, hierarchist, egalitarian, or hierarchical individualist. Early cultural theorists initially referred to hierarchical individualists as fatalists, however, Kahan (2012) discarded this term because it does not necessarily represent all individuals that are express high grid, low group beliefs. Rather than characterizing those who hold these beliefs as having a fatalist (e.g. helpless) attitude toward environmental risks because they feel they have no control over the decision-making that could mitigate these risks (Douglas & Wildavsky, 1983), it might be more appropriate to classify these individuals as those who are aware that there are hierarchies in place around them, but also have awareness that they can control the smaller scale hierarchies (Kahan et al., 2011). This, then, shows the hierarchical individualist as someone who thrives in a setting where they have increased control over their surrounding social circles. Such a cultural way of life is easily
achieved in rural settings where there is inherently more decentralization of power. For this reason, the hierarchical individualist term was used in this study.

The major criticism of cultural theory is that it assumes risk perception is not shaped at the individual scale but, rather, at a societal scale. This goes against the traditional psychometric theories that seek to explain risk perception, which rely on neoclassical notion that individual’s psychological traits dispose how they respond to risks (Kahan, 2012; Slovic, 1987).

Cultural theory has since been tailored to explain individual perceptions to risks by incorporating aspects of Slovic’s (1987) psychometric risk theory where one’s cultural worldview may be “reflected in [one’s] affective appraisals of risk” (Kahan et al., 2011, p. 149). Under CCR, those who may be classified as more individualistic or hierarchist are expected to be “skeptical of environmental risks [because] the widespread acceptance of which would justify restricting commerce and industry” (Kahan et al., 2011, p. 148). Restricting commerce and industry is viewed by individualists and hierarchists as stifling competition. This goes against the values of fostering personal wealth and social status that are perceived as highly important to those who share these cultural worldviews. Conversely, the values of sharing wealth equally and concern for increasing social inequities are characteristic of those who are more egalitarian and communitarian in nature and result in heightened perceptions of risk precisely because the risk-causing agent is so often commerce and industry, entities blamed for increasing such social and economic inequities. In this way, egalitarian and communitarian individuals accept such risks because they conform to the way such these cultural types view the world, a world in which commerce and industry distorts human nature into acting selfishly at another’s expense.
CCR has proven particularly salient in explaining polarized views of climate change, which is largely why it was focused on for this study. For instance, Kahan et al. (2012) conducted a study comparing the relative weight that cultural biases and science comprehension (which is the main driver of the psychometric thesis) contribute to public risk perceptions and found that cultural biases play a much larger role than science comprehension when members of the public evaluate the risk of climate change. It is expected that CCR can help to explain some of the variation in perceived acceptability to forest adaptation strategies.

If one views the world from an individualistic perspective, nature is seen as benign (i.e. resources are not depleting) (Thompson et al., 1990). Individualists are likely to perceive adaptation scenarios in one of two ways. First, this cultural group is less likely to perceive climate change as a risk and thus could dismiss strategies such as assisted migration that address direct climate change impacts, deeming them an unnecessary disruption to economic return. Second, this cultural group could actually perceive certain adaptation strategies as acceptable because they have the potential for significantly increasing profits. For instance, the use of exotic fast growing species and GM technologies would be seen from this perspective as beneficial. In contrast, egalitarians subscribe to the idea that natural resources are depleting and that the natural environment is in a precarious equilibrium and one must address these issues by moderating human behaviour (Steg & Sievers, 2000). From this perspective, intervening in the environment may be viewed as an unacceptable move because we should be moderating our own behaviours and needs. These individuals would be more likely to respond to the notions of assisted migration and genomics as a waste of resources. Hierarchists blend these opposing views by subscribing to the notion that resources are scarce, but that humans have the ability to manage them sustainably and that this just requires scientific experts who dictate the terms of sustainable management. Thus, these individuals would likely support
adaptation strategies (e.g. assisted migration and genomic-based selection methods) that were mandated through government. Hierarchical individualists might be more likely to resist adaptation strategies simply based on the notion that they do not believe that the provincial government should be involved in local land-use decisions. These individuals may indeed be experimenting with adaptation (such as assisted migration) on the local scale.

As alluded to above, another element that makes cultural theory of environmental risk perception relevant to this project is the fact that it unites individuals’ cultural bias, their beliefs toward environmental risk, and the proposed solutions that they would deem acceptable (Steg & Sievers, 2000). In this study, the role CCR might play in forming individuals’ perceptions of climate change adaptation strategies that could theoretically be implemented in Western Canada’s forests was explored. Specific research questions are put forward in the next section.

### 2.5 Research Questions

From the literature, two dominant research questions emerged representing current gaps in knowledge:

1. How does perceived acceptability of a range of forest management climate change adaptation strategies and outcomes vary among forest-dependent community members?

2. Can the cultural cognition of risk theory be used to better explain variation in public perception towards these forest management climate change adaptation strategies?

The benefactor of this research, Genome Canada, policy makers, as well as the geneticists working on this project wished to understand the perceived acceptability of different modes of assisted migration. For these stakeholders, understanding perceptions toward migration distances and the use of genomics to inform the process is crucial for implementing policy and management changes. However, observing public perceptions on such a narrow
range of nuanced technical concepts may not derive meaningful results. The general public has very low levels of knowledge of both genomic applications and assisted migration, especially in the context of forestry (Aubin et al., 2011; Hall, 2007). For this reason, this discussion was nested within a set of potential forest adaptation strategies that represent varying degrees of human intervention in forest ecosystems. By including a range of potential adaptation strategies, participants were better able to contextualize the concept of assisted migration and distinguish between transgenic and non-transgenic genomic technology.
Chapter 3  Methods

3.1 Research Design and Rationale

In seeking the most appropriate methods for addressing the research questions (Section 2.5), the nature of the research itself must be considered. There are two modes by which social research is approached: qualitative and quantitative. Each possesses its set of strengths and weaknesses. For instance, quantitative social data has the benefit of allowing the researcher to explain issues in a way that is statistically sound and, oftentimes, generalizable to a population. However, there are a number of limitations with reducing social phenomena down to numerical information. The largest limitation is the loss of detail and reasoning behind the statistical conclusions (Babbie & Benaquisto, 2002). Without full knowledge of the drivers behind attitudes, policies based on exclusively quantitative data may fail. Qualitative methods of research, which focus on assembling narratives from research subjects in the forms of interviews and case studies, lack the generalizability and compactness of quantitative datasets; however, they provide a deeper understanding of the mechanisms that inform variation in social phenomena (Creswell, 1998).

Given the low levels of public awareness of genomics and assisted migration in the context of forestry, conducting an exclusively quantitative inquiry would likely not produce very meaningful results (Aubin et al., 2011). Therefore, in considering the first research question – how does perceived acceptability of a range of forest management climate change adaptation strategies and outcomes vary among forest dependent community members? – it was decided that a qualitative exploration of perceptions was more appropriate. This allows for important themes in perceptions to emerge in an interview setting and narratives to be followed (Rubin &
Chapter 3

Rubin, 2005). For the second research question, which is testing the influence that Cultural Cognition of Risk theory has over informing perceptions to forest adaptation, quantitative research tools were more appropriate (Babbie & Benaquisto, 2002).

Ultimately, this meant that a mixed methods approach was employed across the study to provide the deepest analysis of the research questions. Layering qualitative and quantitative methods allows for the researcher to triangulate results. By approaching the research from multiple angles, once can mitigate the risks of relying on any one given method (Singleton Jr. & Straits, 1999). Also, through the layering this research, a deeper understanding of the mechanisms that inform perceptions are discerned, creating a sound foundation for designing more targeted projects in the future.

For the qualitative inquiry, focus groups were employed to generate discussion around the research questions. The focus group interview format was chosen because the topics under study (genomics, forest management, and climate change) are not concepts that laypeople necessarily know well (Aubin et al., 2011). Focus groups enabled the provision of some tutorial materials, in addition to providing time to allow for a deeper understanding of the knowledge and moral logics that underpin participants’ perceptions when confronted with new topics. The group interviews were conducted in a structured qualitative format to keep the discussion from straying from the research objectives, while allowing for participants to elaborate on their responses. This is critical when approaching a population that does not have specialized knowledge. The ability of participants to build on each other’s thoughts may also provide a clearer idea of the drivers of risk and acceptability than would be attained through one-on-one interviews (Stewart et al., 2007). Additionally, there was also incentive to obtain a large enough sample size to
derive meaningful results for the quantitative components of research, which is more attainable by conducting group interviews.

Quantitative data was also collected from each focus group participant during the focus group interviews. To triangulate the results of the focus group interviews as well as provide the appropriate mode of data for answering the second research question, a Q sort trade-off exercise was designed following Q methodology. Q sorts are a way of measuring variation in subjective phenomena where the researcher prepares a series of statements that represent the range of possible subjective attitudes towards a topic of interest (Brown, 1996). Q methodology was selected specifically for its qualities of producing “sharper and more systematic insights into the values and preferences held by the public”, which combined with focus group data, makes it an ideal research method for informing policy makers (Steelman & Maguire, 1999, p. 386). For smaller sample sizes, Q sorts are statistically stronger than administering more conventional survey instruments and the focus group format allows for less time to be spent on instructing individual participants on how to organize the sorts (Stainton, 1995).

In order to gather basic socio-demographic data on the research participants, as well as to collect data for addressing question two, a four-page, fixed choice survey instrument was also designed and administered to participants during the focus groups. Surveys provide an easy way to assemble standardized datasets that measure socio-demographic and attitudinal variables (Babbie & Benaquisto, 2002).

3.2 Case Study Communities

Results from four case study communities were analyzed in this research (Yin, 2003). Four criteria were used in selecting communities for the study. First, rural communities were
studied because these communities are more likely to be directly impacted by changes in forest management. Second, only communities that fall within actively harvested forest areas that are managed for the production of lodgepole pine and interior spruce were considered because lodgepole pine and interior spruce are the dominant commercial species harvested in Western Canada (BC Ministry of Forests Mines & Lands, 2010; Larabie, 2011) and they are presently the target species being considered in adaptation strategies. The geographic scope of the larger Genome Canada project was BC and Alberta and, consequently, two communities were selected from each province. From a research perspective, this is relevant because of the vastly different relationships that citizens of BC and Alberta possess with forests. Lastly, economic dependence on the forest sector was an important in this study and, therefore, was an important consideration in determining the most appropriate communities to case study. Specifically, two communities (one in each province) were chosen that had high levels of forest dependence (FD) and two communities (one in each province) were chosen that had more mixed economic bases. In accordance with Stedman et al. (2007), community FD was calculated by dividing employed labour force employed in forestry and forestry support sectors by the total employed labour force.

Using the above criteria led to the following communities being selected: Quesnel, BC; Golden, BC; High Level, Alberta; and Athabasca, Alberta. Specifically, Quesnel and High Level were selected for their relatively high FD, whereas Golden and Athabasca both represent rural communities that have more mixed economies. As seen in Figure 3-1, the communities are widely distributed and accordingly possess distinct geographical surroundings and differing forest industries.
Quesnel is located in the Cariboo regional district of BC. It possesses the highest population amongst the case study communities, with a municipal population of 9,504 according to the most recent census (BC Stats, 2012). With approximately 50% of its municipal tax revenue and 27% of its employed labour force coming from forestry-related activities, Quesnel is one of the most FD communities in BC. The timber supply area (TSA) of Quesnel is 2.1 million ha with “70% of the total mature volume” being lodgepole pine (BC Government, 2012, p. 2). Presently, the allowable annual cut (AAC) is 4.0 million cubic metres, which has been
uplifted from its historic 2.3 million cubic metres because of the need to harvest beetle-killed wood from the mountain pine beetle (MPB) outbreak that targeted the lodgepole pine in the region. These harvest levels are expected to fall abruptly as the MPB fibre volume is liquidated in the next 15 years to as low as 1.15 million cubic metres. This places Quesnel in a uniquely vulnerable position economically and an interesting place elicit perceptions, especially given the direct influence of climate on the MPB outbreak.

Golden is located in the Columbia-Shuswap regional district of BC. It comprises a smaller population (3,858) than Quesnel, but this community possesses a more diverse economy. With a successful ski resort and its location in the Canadian Rockies, activities supporting tourism and recreation contribute significantly to the town’s economy. Even though harvesting plays a relatively less important role in the Golden economy, the opening of the Lousiana Pacific plywood mill in 1999 retains forestry-related employment at approximately 13% of the total employed labour force (Massey, 2006; Statistics Canada, 2011). The Golden TSA encompasses 921,231 hectares, with an AAC of 485,000 cubic metres (Ministry of Forests Lands & Natural Resource Operations, 2011). With more small-scale forestry operations in place and topographically diverse local geography that supports a diverse species mix of interior spruce, Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine, and to a lesser extent, sub-alpine fir (*Abies lasiocarpa*), hemlock (*Tsuga spp.*), and western red cedar (*Thuja plicata*), eliciting perceptions in Golden was of interest because of its relatively lower vulnerability to direct climate impacts compared to the other BC community of Quesnel.

High Level (population: 3,887) was selected as a case study for its relatively high FD – for Alberta standards – of 13.12% (Alberta Community Profiles, 2014b; Statistics Canada, 2012). High Level is located in the Northern Peace River District. The Forest Management Area
(FMA, equivalent to TSA in BC) is 3.5 million ha, with harvestable area that covers approximately 1.8 million ha (Environment & Sustainable Resource Development, 2012). The dominant species of harvest is black spruce (*Picea mariana*) (Tolko Industries Ltd., 2012). Attempts to diversify the rural economy resulted in the construction of the northernmost industrial grain elevator in Canada. Additionally, there are oil fields that also support local employment (Alberta Community Profiles, 2014b). High Level was an interesting community for study because it is very isolated from forest products markets, making it uniquely vulnerable to economic fluctuation in that, when there are economic downturns, transportation costs make it less economic to harvest in the region.

Athabasca is located in the Northern Edmonton District of Alberta. With a population of 2,575, it is the smallest community in this study (Alberta Community Profiles, 2014a). The economic base of Athabasca is largely founded on industrial agriculture; however, it is supported by forestry, natural gas, and tourism (Alberta Community Profiles, 2014a). The forestry FMA is large, encompassing nearly 7 million ha and supporting 2 million ha of harvestable land (Environment & Sustainable Resource Development, 2012). Athabasca was an interesting case study because the expansive FMA is largely located north of the township, which could influence perceived acceptability of management because many residents may not directly see the effects of forest management and, subsequently, could be less concerned about the management techniques that foresters employ.

### 3.3 Social Groups

Within each case study community, effort was made to assemble three focus groups representing three social groups of interest to this study. The composition of each group was kept uniform in order to allow for the deepest discussion amongst participants and easy
comparison between the communities (Stewart et al., 2007). However interesting it would have been host heterogenous groups to study the group dynamics at play between people who possess different connections to the forest, such data was beyond the scope of this study.

In determining which social groups to target for each community, a pragmatic approach was employed. Perceptions of Registered Professional Foresters (RPFs) – referred to throughout this study as foresters – were considered highly relevant because these individuals would be the end-users of any adaptation strategy. Additionally, the local knowledge derived from working in the forest provides a uniquely informed perspective of how human intervention can affect the landscape. Another social group that was of interest for this study was environmentalists. Environmentalists are thought to be particularly sensitive to human intervention in nature and it was assumed that people who identify as environmentally conscious would provide a unique perspective on the balance between wanting to minimize human changes on the landscape and adapting to climate change. Lastly, groups of business owners and managers were assembled based on the rationale that it would interesting to hear perspectives from active members in the community who might not necessarily possess specialized knowledge. This is a critical perspective for broadening understanding of how those who may not be thinking about forest adaptation respond to the risks of different adaptation strategies, which has thus far not been studied in the literature (Aubin et al., 2011). First Nations are another social group that would be of obvious interest to engage on the issues discussed in this study; however, the relationship building required to respectfully conduct research within neighbouring First Nation communities was also beyond the scope and timelines of this study.

Recruitment for the focus group participants was accomplished in a variety of ways. For foresters, the directory of RPFs was used to look up the practicing foresters in each of the case
study communities and contacted by way of phone call and email. For environmentalists, research was conducted on any local environmental groups, which were subsequently contacted by phone and email. For the business owners and managers, local business directories were used to contact and recruit participants via phone. Per the Canadian Tri-Council Policy Statement protocol on the Ethical Conduct for Research Involving Humans, participants were provided with a formal letter of introduction that outlined the project, and stated that anything shared in the groups would only be presented in an anonymous format (Babbie & Benaquisto, 2002; Canadian Institutes of Health Research, Natural Sciences & Engineering Research Council of Canada & Social Sciences & Humanities Research Council of Canada, 2010). Once individuals arrived at the focus group sessions, time was spent at the beginning going over the project aims and scope, as well as outlining their rights as a research participant. In addition, permission was sought for audio-recording each focus group session. Once each of these components was understood, written consent was obtained and the focus groups began.

3.4 Methodological Approaches

3.4.1 Research Question 1

In seeking to answer the first research question, “how does perceived acceptability to a range of forest adaptation strategies and outcomes vary among forest-dependent community members?”, the challenges of eliciting public opinions on topics that they may not know very much about had to be carefully considered. Focus groups were pursued as the first method to explore perceptions because they allow participants to discuss topics in a group, leading to deeper discussion (Stewart et al., 2007), and allowing for any misperceptions to be observed. A secondary challenge was getting participants to think about forest management in the
appropriate time scale. Because trees are such long-lived species, reforestation occurring now will have impacts 60 to 100 years into the future. For a layperson, the long time horizons of forest management can be hard to comprehend. Consequently, the focus groups provided an opportunity to give some tutorial information on forest-climate interactions.

With all of these variables considered, an interview schedule was designed to accommodate the need to build the public’s capacity to have informed opinions regarding the set of forest adaptation strategies presented. To begin each focus group, participants engaged in a discussion of forest values. The objective of this was to put the participants at ease. Following this, tutorial information on climate change and forests was provided to set the context for a discussion on adaptation and to observe if participants attributed local disturbance events to global climate change. First, the moderator asked the following question: “have you observed any changes on the local landscape that you attribute global climate change?”. Once a short discussion transpired, the moderator introduced the concept of forest ecological zones – in BC the Biogeoclimatic Ecosystem Classification (BEC) zones were used and in Alberta the Alberta Natural Sub-Regions system was used – explaining that these regional zones are based on local climates, geography, and species. After this was explained, the following information was provided:

Over very long periods of time, tree populations adapt to the local climate and soil conditions in which they grow. As the global climate continues to change, forests are expected to become poorly adapted to the areas in which they are growing presently. This means that they will grow less vigorously and be more vulnerable to insect and disease outbreaks.

Following this, projections for forests (at the Western Canada and TSA/FMA scale) were shown at the present day (as a baseline), 2020, 2050, and 2080 stages. These were derived from a consensus climate model, which bases its projections on 20 models that “represent the
range and distribution of equally plausible future climates”, showing only the climatic shifts that all 20 models project will happen (Wang et al., 2012, p. 129). Colours on the projected maps

![Maps showing forest projections](image)

**Figure 3-2:** An example of the Western Canada-scale Alberta Natural Subregions forest projections for changing climates over time shown in the Alberta focus groups (Gray et al., 2011).

(see Figure 3-2 and Figure 3-3 for examples) represent the ecological niches – shown in the form of BEC zones in the BC focus groups and Alberta Natural Subregions in the Alberta focus groups – to illustrate the effects of a changing climate on forests. During this time, participants were allowed to ask questions about the projections. Once the tutorial was finished, a discussion of the forest adaptation strategies ensued.
For the qualitative discussion on forest adaptation, three scenarios were designed and communicated: 1) forest managers plant selectively bred seedlings grown from seeds that are collected from forests close to the planting area; 2) forest managers plant tree seedlings grown from seeds that come from non-local forests (i.e. forests that are distant from the planting area but within the species range), and genomic tools are used to select seeds that are expected to grow well in the climate conditions expected to occur in the near future; and 3) forest managers plant seedlings grown from seeds that are genetically engineered (GMOs) to grow well in the climate conditions expected to occur in the near future. This range of scenarios was selected to foster discussion on the different applications of genomics, the role of conventional tree breeding, and seed movement.
It was thought that it would be challenging to communicate the technical concepts involved in these adaptation strategies. In an effort to experiment with different ways of communicating the technical concepts of forest management over time, ecosystem visualizations were developed depicting a future forest landscape that could plausibly take place as a result of the given management strategy (Lewis & Sheppard, 2005). This was accomplished by selecting a recognizable forested area within each of the study community TSA/FMAs and using GIS spatial data on the BEC Zone subzones to inform the visualization of the forest landscape in VSN 2 visualization software (see Appendix A for specific data sources used to inform the creation of the visualizations).

For each community, baseline “present day” visualizations were developed first. Specifically, the forest was populated with the three most commonly occurring tree species according to indicated species abundance information (Ministry of Forests, 2002; Steen & Coupé, 1997). In the case of Quesnel, where there is extensive beetle kill in the resident pine forests, the present day visualization incorporated the imprint of this disturbance at present day concentrations (Carroll, personal communication, September 4, 2012). Following this, the status quo (planting local selectively bred seed according to traditional regional seed zones) visualization was developed by planting the same species as in the baseline image and imposing plausible biotic disturbances on the landscape. The second scenario (assisted migration of commercially important tree species) showed the local landscape populated with the three most commonly occurring tree species according to the species abundance information indicated in the BEC zones as projected by Wang et al.’s (2012) consensus ecosystem climate niche model approach (Ministry of Forests, 2002; Steen & Coupé, 1997). The third scenario was developed by imposing a four foot x four foot spaced monoculture plantation of genetically engineered conifers. The plantation style was chosen based on
Canada’s regulatory framework for containing species with novel traits (Bonfils, 2006). Forest ecologists in the Faculty of Forestry were consulted in order to inform the degree to which natural disturbance was present on the landscape for each region and under each scenario (Carroll, personal communication, September 4, 2012; Simard, personal communication, September 10, 2012).

In the first two case study communities, the adaptation scenarios were introduced with the aid of these ecosystem visualizations. However, the visualization method proved too controversial and distracting to the discussion, so the adaptation strategies were introduced in an exclusively verbal manner in the remaining two communities. Once all three adaptation scenarios were introduced, time was taken for participants to discuss each individual scenario for perceived acceptability. See Appendix B for the full focus group interview schedule.

For the Q sort exercise, nine forest adaptation scenarios were designed and described to represent nuanced variations in management techniques (see Table 3-1). Each adaptation scenario had a randomized alphabetical code associated with the statement to allow for easy transcription of the data. The adaptation scenarios were printed on separate cards and each participant was given the stack of cards and asked to arrange the statements in the shape of a normal-distribution, where the right end of the distribution would be populated with the statements that the individual found most acceptable and the left end with statements that were considered least acceptable (Amin, 2000; Webler et al., 2009). Photos were taken of the sort for later analysis (Figure 3-4).
Table 3-1: The nine scenarios (and associated nicknames) designed for the Q sort exercise (AM refers to scenarios that are assisted migration-based and GM refers to the scenario that is premised on genetic modification).

<table>
<thead>
<tr>
<th>Nickname</th>
<th>Q Statement Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>No replanting after harvest</td>
<td>Forests are left to naturally regrow after harvest and nature take its course.</td>
</tr>
<tr>
<td>Local, no breeding, mix spp.</td>
<td>Seedlings grown from seed collected locally composed of a wide variety of locally occurring tree species are planted after harvest.</td>
</tr>
<tr>
<td>Local, no breeding, conventional timber spp.</td>
<td>Seedlings grown from seed collected locally composed of conventional timber species are planted after harvest.</td>
</tr>
<tr>
<td>Local, selectively bred, conventional timber spp.</td>
<td>Local seed of conventional timber species is collected and bred to produce healthy and vigorous seedlings that are planted after harvest.</td>
</tr>
<tr>
<td>AM, selection based on climate model, conventional timber spp.</td>
<td>Seedlings grown from seed collected from non-local forests chosen based on future climate matching composed of conventional timber species are planted after harvest.</td>
</tr>
<tr>
<td>AM, selection based on genomics and climate, conventional timber spp.</td>
<td>Scientists use genomic tools and climate matching to select the healthiest and most vigorous seedlings from seed collected in non-local forests and plant them after harvest. Only conventional timber species are actively planted.</td>
</tr>
<tr>
<td>AM, selection based on climate model, mixed spp.</td>
<td>Seedlings grown from seed collected from non-local forests composed of a wide variety of species that scientists project are climatically matched.</td>
</tr>
<tr>
<td>Exotic fast-growing spp.</td>
<td>Seedlings grown from exotic fast growing species are planted after harvest.</td>
</tr>
<tr>
<td>GM to maximize timber production</td>
<td>Seedlings grown from seed of conventional timber species that have been genetically engineered to maximize timber production in the projected climate.</td>
</tr>
</tbody>
</table>

The first stage of the analysis focused on the Q sort data because it provided a good overview of perceptions observed across the study. The statements for each participant’s Q sort were first converted into a numerical dataset, where adaptation scenarios ranked as the most acceptable were assigned a value of 5; scenarios that were ranked as acceptable, assigned a value of 4; scenarios that were ranked as indifferently, a value of 3; scenarios that were ranked as less acceptable, a value of 2; and scenarios that were ranked as least acceptable, a value of 1 (Figure 3-4). Once all of the Q sort data was converted into numerical form, the mean placement of each adaptation scenario was calculated segmented by focus group, social group, and case study community. To test for significant differences in means, one-way analyses of variance (ANOVA) and Scheffé tests were used at alpha = 0.05 (Bluman, 2007).
Figure 3-4: An example of an individual’s Q sort with numerical codes assigned to the adaptation scenarios based on where the participant placed the scenario on the Q sort mat.

The qualitative data was analyzed in two ways. First, the interviews were transcribed verbatim and coded for structure (i.e. interview section, case study community, social group, etc.). Following this, the text revolving around each forest adaptation scenario discussion was coded for affect (i.e. positive, neutral, negative). This allowed for a reflection period and for emergent themes to be noted. Transformative mixed methodology was employed to calculate the frequency of positive, neutral, or negative reactions toward the adaptation scenarios (Creswell, 2014). The second layer of analysis involved extracting quotes that reflected emergent themes in the interviews to illustrate narratives around the quantitative data (Denzin & Lincoln, 1998).

3.4.2 Research Question 2

A quantitative approach was used to answer the second research question, “can cultural cognition of risk theory be used to better explain variation in public perception toward these
forest management climate change adaptation strategies?” All of the participants in the study were first segmented into the four cultural worldview types identified in Cultural Cognition of Risk (CCR) theory (discussed in Section 2.4): individualist; hierarchist; hierarchic individualist; and egalitarian. To accomplish this, Kahan’s (2012) scale – a set of Likert statements, which elicit attitudes toward a variety of social and political issues designed to classify an individual’s cultural worldview – was used to identify each participants’ cultural worldview. This scale was adapted for a Canadian audience in that certain social and political subjects that (in Kahan’s (2012) original scale) refer to the United States and were adjusted accordingly to reflect parallel Canadian topics. The adjusted scale can be seen in Table 3-2. In Kahan’s (2012) terminology, half of the statements in this scale refer to beliefs and attitudes associated with the “grid” way of life and a half of the statements refer to the beliefs and attitudes associated with “group” way of life. For each statement, the participants were instructed to select the answer that was most reflective of their attitude from the following options: strongly agree (value of 5); agree (value of 4); neither agree/disagree (value of 3); disagree (value of 2); or strongly disagree (value of 1). The scale for statements associated with low “grid” and “group” ways of life are reversed. Each participant was assigned a group score and a grid score based on their responses to the statements and this was used to identify their cultural worldview.

The surveys were administered before the focus groups commenced and the data was transformed into numerical codes according to Kahan (2012) (see Table 3-2). For each participant, the mean group score and a mean grid score were calculated. These scores were subsequently converted into orthogonal scores, where a value of three was assigned to the intersection of group and grid axes. Positive values on the orthogonal group and grid axes were those values greater than three and negative values were those less than three. Once this was done, a participant’s place in cultural
Table 3-2: Adapted Kahan (2012) scale for identifying an individual’s cultural worldview.

<table>
<thead>
<tr>
<th>Number</th>
<th>CCR</th>
<th>Statement</th>
<th>Final Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Group</td>
<td>Sometimes government needs to make laws that keep people from hurting themselves.</td>
<td>5,4,3,2,1</td>
</tr>
<tr>
<td>2.</td>
<td>Grid</td>
<td>We have gone too far in pushing equal rights in this country.</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>3.</td>
<td>Group</td>
<td>The government interferes far too much in our everyday lives.</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>4.</td>
<td>Grid</td>
<td>We need to dramatically reduce inequalities between the rich and the poor, whites and people of colour, First Nations, and men and women.</td>
<td>5,4,3,2,1</td>
</tr>
<tr>
<td>5.</td>
<td>Group</td>
<td>It’s not the government's business to try to protect people from themselves.</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>6.</td>
<td>Grid</td>
<td>Our society would be better off if the distribution of wealth was more equal.</td>
<td>5,4,3,2,1</td>
</tr>
<tr>
<td>7.</td>
<td>Group</td>
<td>The government should stop telling people how to live their lives.</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>8.</td>
<td>Grid</td>
<td>It seems like minority groups don't want equal rights, they want special rights just for them.</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>9.</td>
<td>Group</td>
<td>The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.</td>
<td>5,4,3,2,1</td>
</tr>
<tr>
<td>10.</td>
<td>Grid</td>
<td>Society as a whole has become too soft and feminine.</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>11.</td>
<td>Group</td>
<td>Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.</td>
<td>5,4,3,2,1</td>
</tr>
<tr>
<td>12.</td>
<td>Grid</td>
<td>Discrimination against minorities is still a very serious problem in our society.</td>
<td>5,4,3,2,1</td>
</tr>
</tbody>
</table>

group grid map could be determined as hierarchist (positive group score, positive grid score), egalitarian (positive group score, negative grid score), individualist (negative group score, negative grid score), or hierarchical individualist (negative group score, positive grid score). The participants were then clustered into their cultural worldviews and the Q sort means of these clusters were calculated. In doing so, the role of CCR in shaping risk perceptions of the adaptation scenarios could be analyzed. To test for significant differences, ANOVA and Scheffé tests were used at alpha = 0.05 (Bluman, 2007).
Chapter 4 Results

Following are the results from data collected in the four case study communities. Arranged by research question, Section 4.1 highlights the Q sort trends in perceived acceptability by community and social group and integrates findings from the qualitative focus group interviews. Summary statistics are also provided for each community, emanating from the study-wide thematic and Q sort analyses. Section 4.2 shows the Q sort trends in perceived acceptability segmented by cultural worldview.

4.1 Question 1 Results

4.1.1 Quesnel, BC

Quesnel was the first community visited. Recruitment for the study was strongest in this heavily forest-dependent community, with a total of 18 participants turning out for the three focus groups (see Table 4-1). The forester focus group consisted of six participants (with a mean age of 49) representing the spectrum of forestry roles seen in the Quesnel TSA. Specifically, there were individuals working as small-scale consultants, those working with the adjacent Aboriginal community, and those working for larger scale forestry companies, as well as the Ministry of Forest Lands & Natural Resource Operations. Five individuals participated in the business focus group representing recreation other resource

<table>
<thead>
<tr>
<th>Table 4-1: Number of participants in Quesnel focus groups broken down by social group and gender.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total # of Participants in Quesnel</strong></td>
</tr>
<tr>
<td># of Forester Participants</td>
</tr>
<tr>
<td># of Business Participants</td>
</tr>
<tr>
<td># of Environmental Participants</td>
</tr>
</tbody>
</table>
sectors and consultants. The average age of the business group was 53. The seven environmental participants were recruited by way of a local environmental group with the average age being 59. The highest levels of education reported were seen in the environmentalist focus group, with 43% having obtained a Masters degree (see Figure 4-1). Half of the forester participants had obtained four-year university degrees.

![Figure 4-1: The highest level of education obtained by Quesnel participants represented as a proportion of members within a group.](image)

Data on the participants’ connections to the forest sector was collected in the entry survey as a way of determining any vested interest or knowledge that the groups might have with forestry practices. The participants across all focus groups in the Quesnel case study had relatively strong ties to the forest sector, with nearly 60% of both the environmental and business participants reporting having worked in the forest sector in the past and participants from all groups reporting having family that has worked in forestry (Figure 4-2).
Regarding the perceived acceptability of different forms of forest management in Quesnel, there were some notable trends. As seen in Figure 4-3, there was a significant difference in attitudes toward the management scenario that represented planting local, selectively bred, conventional timber species. Specifically, forestry participants rated this scenario as significantly more acceptable than environmental participants. In considering the scenarios that utilize assisted migration, there was a distinct convergence in attitudes toward the scenario that represented assisted migration based on genomics and climate, utilizing conventional timber species. Specifically, this scenario was perceived as the least acceptable among the three assisted migration-based scenarios.

Another notable difference arose in the perceptions toward assisted migration based on climatic modelling that utilized mixed species. Environmental participants’ attitudes were
significantly different from participants in both the business and forester groups. It is useful to note that this scenario was deemed the most acceptable of the three assisted migration scenarios by both environmental and business focus groups, while participants in the forestry focus group deemed all three assisted migration scenarios as distinctly less acceptable than those involving local seed.
Figure 4-3: Perceived acceptance of the nine Q sort forest management scenarios as reported by Quesnel focus groups, where the y-axis values denote the mean rating of perceived acceptability (1 = least acceptable; 2 = not very acceptable; 3 = indifferent; 4 = more acceptable; 5 most acceptable). AM refers to assisted migration and GM refers to genetic modification. Circles denote where ANOVA and Scheffé tests revealed significant differences (at alpha = 0.05) in the way that different focus groups perceived a given scenario. Notes indicate where the differences exist with Xf, Xe, and Xb denoting mean scores for Foresters, Environmentalists, and Business Community respectively.
Chapter 4

A number of themes emerged in the qualitative interviews. In discussing the first (local-based) scenario, there was generally a mixed response both across and within groups. Forester participants expressed clear preference toward the local-based scenario, indicating that the recently planted local trees were getting strong leader growth attributable to the warmer weather. There was discussion of enhancing the resilience of stands by maintaining good genetic diversity in the selected seed. Environmental participants perceived the local scenario as acceptable on the condition that it incorporated a “true mixed planting [because] maybe the firs will survive, maybe the ponderosas will survive”. This is reinforced in the Q sort results with environmentalists perceiving the mixed local seed source scenario as the most acceptable.

There was also acknowledgment that climate was already increasing disturbance on the landscape, with one participant remarking, “It doesn’t sound to me like those trees that are currently here are able to adapt to the changing conditions remotely quick enough and it looks like that [referring to assisted migration scenario visualization] already”. Another participant expressed that there must be reserves of land that are just allowed to naturally change because “worlds evolve, things happen, you have to make space for the totally natural change that comes with the climate change. How the forest itself is going to change without… human intervention”.

The business participants focused much of the conversation on marketability of local wood sources. This was brought about because, while speaking about the hemlock, cedar, and cypress growth, one participant indicated that some local seed sources could benefit from the warmer weather projected to come into the area based on the participant’s observations that the longer growing seasons are beneficial. In response to this notion of other local species growing under more suitable conditions as a result of climate change, one participant remarked,
“...you're not going to sustain the forest industry on cedar... because it rots and it's just junk wood. And balsam, I mean nobody wants balsam, nobody wants cedar, and if they are start becoming the dominant species, well then you can just close more mills”.

Regarding the second assisted migration-based scenario, several of the forestry participants were wary of incorporating non-local provenances into plantings. The dominant skepticism of using non-local provenances for seed source was that they would fail to establish as suitable climatic conditions are not yet here. Citing the recent seed transfer zone change for Western larch (*Larix occidentalis*), which allows forest managers to incorporate larch seedlings into plantings, one participant remarked, “there are some great trials and there are some failures”. Another participant said, “…like recently, they allowed a couple of seedlots of western larch into certain subzones, and I went what? Western larch? Where is the closest Western larch growing? Cranbrook? Why would you move western larch up here, because you think maybe humans are causing climate change, because you know? It’s gonna fail! It’s gonna fail! I can predict real clear. So its when we get to the silliness… yeah, you know, I can build resilience into my plans, great, yeah that’s smart, I should do that, but its when you get to the silliness […]”. Additionally, a participant made a comment that maybe adaptation would have to occur; however, it was not likely necessary for at least one rotation.

Environmental participants were most concerned about maintaining a diversity of management strategies on the landscape. Attitudes in the business group were more pragmatic. Assisted migration was thought to be an acceptable practice, as long as it was done in moderation. One participant exemplified this attitude by describing that, as long as new seeds sources are slowly introduced into the edges of habitats that they already grow in so that effects could be monitored and somewhat contained, then assisted migration could be a useful practice
to mitigate the impacts of climate change on the land-base. Some of the participants in this group were more concerned with the marketability of trees, while others were most concerned about maintaining a diverse species mix.

In discussions about the third scenario that features GM techniques, there was general consensus among groups that genetic modification was an unacceptable method to use in forestry. Reasons ranged from a discomfort of GM use in other domains (namely, food products), the ethical issues surrounding corporate control that goes with the use of GM, and a general skepticism of the human capability to control genetics and accurately forecast long-term effects. Specifically, forester participants made reference to the notion that altering the genetics of a tree could make it less resilient and adaptable. There were also comments that GM seed would just fail to establish. Within the environmental group, participants related GM forests to science fiction and made reference to the fact that focusing efforts on genetically modifying one species does not consider the ecosystem level interactions. The business participants emphasized the notion that, although the seed could be deemed safe, there are no long-term observations available and, therefore, there could be unforeseen consequences. Participants in this group were also uncomfortable with the use of GM in other domains.

4.1.2 Golden, BC

Golden was the second community visited. Twelve individuals were recruited from this community for the study: four participants showing up for each of the three groups (Table 4-2). The forester participants from Golden were all working in small-scale operations, in roles ranging from silviculture to management consulting. The mean age of the forestry group participants was 50. The business group consisted of a diverse mix of backgrounds ranging from business consulting to store owner, with a mean age of 46. The environmental participants
were mostly recruited through a local environmental group and word of mouth and most had biology and forestry backgrounds. The mean age of this group was 52. The participants from Golden represented a wide spectrum of educational backgrounds with 50% of foresters and environmentalists possessing Bachelor degrees (see Figure 4-4).

Table 4-2: Number of participants in Golden focus groups broken down by social group and gender.

<table>
<thead>
<tr>
<th>Golden</th>
<th>Male</th>
<th>Female</th>
<th>Not Reported</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total # of Participants in Golden</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td># of Forester Participants</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td># of Business Participants</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td># of Environmental Participants</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Compared to Quesnel, there were less personal connections to the forest sector reported by participants (see Figure 4-5). However, 75% of both environmental and forester participants reported having family that has worked in the sector, while 75% of the business group participants reported having no familial or personal connections.

Figure 4-4: The highest level of education obtained by Golden participants represented as a proportion of members within a group.
The most striking trend observed in the Golden focus groups is that the perceptions amongst groups converged for most of the scenarios (Figure 4-6). Broadly speaking, the first seven scenarios were perceived as relatively acceptable and the two extreme scenarios as unacceptable. Although there were no significant differences, environmental participants expressed a distinct preference toward the two scenarios that featured mixed species. The forestry participants perceived the local-based mixed species scenario more indifferently. However, in the context of assisted migration, forestry participants perceived the scenario that featured mixed species as relatively more acceptable than the other two assisted migration-based scenarios.
Figure 4.6: Perceived acceptance of the nine Q sort forest management scenarios as reported by Golden focus groups, where the y-axis values denote the mean rating of perceived acceptability (1 = least acceptable; 2 = not very acceptable; 3 = indifferent; 4 = more acceptable; 5 most acceptable). AM refers to assisted migration and GM refers to genetic modification. ANOVA and Scheffé tests revealed no significant differences among social group means in this community.
Forestry participants responded positively to the local-based scenarios, with one forester stating, “just because the climate has changes, whether it has made it warmer or wetter or both doesn’t mean it’s going to be worse for the forest [...]”. One environmental participant remarked, “I think it’s unacceptable because there is too much failure about it, and I think we have created a scenario because we have screwed around with climate, we have screwed around with the ecosystems so badly that we can’t afford ‘natural’ anymore, and it’s the same reason I don’t attempt in my organic garden to grow heirloom tomatoes. I grow hybrid tomatoes that are designed to grow in Northern gardens and mature quickly and do all that, and they probably don’t taste nearly as good as an heirloom tomato but I can’t grown an heirloom tomato.” This split continued in the discussion about the assisted migration scenario, with one participant expressing that, “assisted migration [...] is a very, very scary thing”. Two of the environmental participants were in support of this scenario, indicating that, if planting different provenances or even species can create a healthy forest, then it could “provide better wildlife habitat, better biodiversity potential” and generally be a positive change.

Countering this viewpoint, many of the other participants emphasized the importance of sticking with local seed sources, because this allows nature to run its course and also reduces disruption to the ecosystem that could come with introducing new genotypes. One business participant expressed concern for reduced erosion control if the local seed becomes maladapted (Golden is located along a river). While another business participant stated, “it’s definitely best to keep what is growing in the area, just because we could be completely wrong and using something else might introduce other problems…”, reinforcing the views that some of the environmentalist participants expressed.
One forester participant expressed wariness regarding the assisted migration-based scenario based on the premise that scientists do not know enough about tree genetics to make such changes in forest management. There was significant unrest within the forestry group during the discussion of assisted migration, with one forester participant stating, “it’s a bit scary. I mean we already know, I mean we’ve already got plantations that we thought were very wonderful and we are seeing the naturals are outperforming so… would I want to go to the extreme in genetic selection… not likely. And if this is that extreme, then it would have to be no […]”. This attitude was echoed by the other forestry participants. Generally, the forestry group generally thought assisted migration was unnecessary in the local context because of the high amount of natural bio- and genetic diversity found in the Golden TSA. Another motivation behind the unrest was the notion of increased government intervention in local forest management. Reflecting on past experiences, one participant remarked, “we’ve had cookbooks before”.

In the environmentalists’ discussion about the assisted migration scenario, one participant expressed that, “assisted migration […] is a very, very scary thing”. Contrastingly, two of the participants were in support of this scenario, indicating that, if planting different provenances or even species can create a healthy forest, then it could “provide better wildlife habitat, better biodiversity potential” and generally be a positive change. In considering the assisted migration-based scenario, some business participants expressed concerns with focusing efforts on adapting ecosystems to climate change when efforts should be allocated toward mitigating anthropogenic climate change. One participant in support of facilitating assisted migration stated, “it’s a great edge[…] I think that if you look at your genetic material, it’s a chance to hedge your bet”.


There was consensus that the risks of failure associated with pursuing GM represented in the third scenario were far too high for it to be used in a commercial context. One participant remarked, "[...] you would never have it happen naturally, so it's an impossible scenario in my mind." All environmental participants were against the notion of GM, with one participant remarking, “well, it has no biodiversity and no wildlife” and another indicating that it would negatively impact the tourism industry in the community because people would no longer want to visit. Only one participant in the business group was receptive to the genetic modification scenario, with the rest of the participants against the use of this technique in forest management.

4.1.3 High Level, Alberta

High Level was the most remote community visited, located in northwest Alberta. Recruitment in this community was the lowest, with only seven participants coming out for the focus groups (Table 4-3). Three individuals attended the forestry focus group, representing

<table>
<thead>
<tr>
<th>Table 4-3: Number of participants in High Level focus groups broken down by social group and gender.</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Level</td>
</tr>
<tr>
<td>Total # of Participants in High Level</td>
</tr>
<tr>
<td># of Forester Participants</td>
</tr>
<tr>
<td># of Business Participants</td>
</tr>
<tr>
<td># of Environmental Participants</td>
</tr>
</tbody>
</table>

Alberta Environment and Sustainable Resource Development and industry. The mean age of the forestry participants was 48. Because of the difficulties in garnering participants, the business participants were individuals representing educational and retail positions, as well as a local store owner. The mean age of this group was 48, as well. Only one participant attended the environmental group, resulting in a one-on-one interview format. This participant was in their
20s. The majority of participants in High Level possessed four-year university degrees as seen in Figure 4-7.

![Figure 4-7: The highest level of education obtained by High Level participants represented as a proportion of members within a group.](image)

Despite the high degree of dependence on the forest sector economically, those not working in forestry fields were not that connected to the local forest sector. For instance, the one environmental participant reported having family that works in the forest sector. However, this individual is not originally from Alberta and did not possess much specialized knowledge or attachment to forestry practices in the area. Meanwhile, only one of the business participants who had lived the longest in the High Level area reported having a personal and familial connection to the sector (Figure 4-8).
In the High Level focus groups, although there were no significant differences, there was clear preference for the local-based scenarios. Foresters perceived the assisted migration-based scenarios as relatively less acceptable compared to the other participants in the community. Out of all study communities, the forestry and environmental participants in High Level rated the genetic modification scenario as most acceptable (Figure 4-9).
Figure 4-9: Perceived acceptance of the nine Q sort forest management scenarios as reported by High Level focus groups, where the y-axis values denote the mean rating of perceived acceptability (1 = least acceptable; 2 = not very acceptable; 3 = indifferent; 4 = more acceptable; 5 most acceptable). AM refers to assisted migration and GM refers to genetic modification. ANOVA and Scheffé tests revealed no significant differences among social group means in this community.
Forester participants all perceived the local-based scenario as acceptable, stating that the “seeds are proven to grow here, so I don’t know why they wouldn’t continue to grow here based on what I continue to know from my [experiences]”. One participant indicated that it would be acceptable to continue planting local seed, but as part of a mixture of strategies (e.g. integrating assisted migration). The environmental participant perceived the local-based scenario as acceptable, indicating that the least amount of human intervention in forest management is preferred. In discussions surrounding the use of local seed, business participants uniformly agreed that it was acceptable. The reasons cited were that the best management is done by nature and that using local seed has worked well in the past so, “why change it?”

The assisted migration strategy was also viewed favourably by all forester participants, with one individual stating, “as long as it’s within the species range, like… I think we get ourselves in trouble if we say we are going to switch our forests all over to California pine because that just brings in a whole host of issues and diseases and we don’t even know if it would work”. The environmental participant was also supportive of the second scenario that involved assisted migration, indicating that residents of High Level “are concerned about […] trees, and not so much how those trees came about or their origin, so I think scenarios such as [assisted migration] would be wholly beneficial”. Regarding the assisted migration scenario, one business participant expressed support for scientists, stating, “I don’t see why it wouldn’t be acceptable. If enough research has been done for them to get to the point that they think it might work and it won’t go too wrong, if the trees are the same thing, have the same either genomic tools or whatever they use, trees are going to grow no matter what”. The other business participant who had stated that nature “knows best” asserted that “maybe [assisted migration] will be the course of action that we are forced to take because of economic
conditions.” There was concern expressed by two of the business participants based on the premise that unintended consequences could occur if non-local seed is planted.

All forester participants were relatively uncomfortable during the interviews with the idea of genetic modification, citing ‘gut feelings’ and the need to proceed with caution when using such new science. A large driver in negative perceptions was the lack of long-term research on the effects of GM on trees. According to some, there could be adverse effects to tree growth over the long term that have not been observed yet and it would be a very scary thing to begin observing such effects years after implementing GM on the landscape. The environmental participant expressed a neutral view of the GM scenario, seeing the potential increased economic return as beneficial for the community, but also stating that ecosystems are “extremely delicate” and that manipulating genetic structure could have unforeseen consequences for all of the other organisms that interact with the altered trees. In considering the notion of genetic modification, business participants were uniformly in agreement that it is too risky a practice. One participant stated, “I don’t think humans are able to properly play God”.

4.1.4 Athabasca, Alberta

Athabasca had the second highest recruitment, with 13 individuals participating in the study (Table 4-4). Three RPFs attended the forestry focus group, representing the two largest forestry companies operating in the Athabasca FMA. The average age of the forestry group was 41, making it the youngest group of foresters in the study. Unfortunately, plans to recruit business participants fell through and instead a community volunteer group was recruited for the study. Four individuals from this group were in attendance and the average age of the individuals was 49. Six individuals attended the
Table 4-4: Number of participants in Athabasca focus groups broken down by social group and gender.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Not Reported</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total # of Participants in Athabasca</strong></td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td><strong># of Forester Participants</strong></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong># of Business Participants</strong></td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong># of Environmental Participants</strong></td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

environmental focus group. Recruitment for this group was mainly done through fliers posted in the local college and the average age of the environmental participants was 38. Participants in Athabasca came from diverse educational backgrounds, with the most educated participants coming from the community volunteer group (see Figure 4-10).

![Figure 4-10: The highest level of education obtained by Athabasca participants represented as a proportion of members within a group.](image)

There was a fair amount of connection to the forest sector observed in Athabasca, at least from the environmental group. Fully, 83% of the environmentalist participants reported that they had worked in the forest sector in the past, while the community volunteer group had a significantly weaker connection to the sector (Figure 4-11).
Of the nine Q sort scenarios, Figure 4-12 shows that the foresters generally perceived the local-based scenarios as highly acceptable. Environmental participants perceived these two local breeding-based scenarios as significantly less acceptable than foresters. Both community volunteer and environmental participants displayed a discomfort with the planting of exclusively conventional timber species relative to scenarios that featured a mixture of species. Generally, the three groups had similar assessments of the assisted migration-based scenarios.
Figure 4-12: Perceived acceptance of the nine Q sort forest management scenarios as reported by Athabasca focus groups, where the y-axis values denote the mean rating of perceived acceptability (1 = least acceptable; 2 = not very acceptable; 3 = indifferent; 4 = more acceptable; 5 most acceptable). AM refers to assisted migration and GM refers to genetic modification. Circles denote where ANOVA and Scheffé tests revealed significant differences (at alpha = 0.05) in the way that different focus groups perceived a given scenario. Notes indicate where the differences exist with Xf, Xe, and Xb denoting mean scores for Foresters, Environmentalists, and Business Community respectively.
There was consensus among Athabasca forester participants that the local-based scenario was acceptable. Reference was made to breeding programs being effective in selecting the most “superior trees that can grow from the natural variety that we have and I don’t see climatic variation […] destroying those trees; they will be a viable crop, if we protect them from fire, and do what we can protecting them from insects. But, ultimately, whether you choose a genetically selected or genetically modified you are still going to have those risks of insect outbreak and fire, so going with what have got right now for this crop cycle not a problem”. This attitude of having at least one more harvest rotation to go before having to change management echoes attitudes expressed in the Quesnel forester group.

Regarding the local scenario, the majority of environmental participants were concerned with conventional tree-breeding programs and the loss of genetic diversity that occurs through imposing selection. The rationale was that there might be some genotypes that have been dormant, but as the climatic conditions change, such genes could suddenly come into expression and that this adaptive potential could be lost through selection. Countering this, some environmental participants expressed trust in scientists’ capabilities to select the appropriate trees for replanting. Among the community volunteer participants, there were mixed attitudes toward the local scenario. The positive perceptions among the community volunteers centred around the idea that “you are planting what existed there… more or less putting it back”; “I support this kind of the evolution of local species so it makes more sense to me to go with the ones where the trees have evolved in that local context”. However, there was also uncertainty around the inability for humans to accurately mimic nature and that continued tweaking (by way of selection) inevitably leads to problems.
The concept of assisted migration was received positive. This was influenced by the fact the there is already some spruce seed that is intensively bred – referred to as Region E – that foresters are allowed to plant across broad regions. This seed is very successful and, thus, dampened risk perceptions of introducing comparable changes in seed transfer rules. Additionally, it was noted that assisted migration would be acceptable as part of portfolio of management techniques to avoid risks that occur from “putting all your eggs in one basket”.

The only elements of uneasiness around the assisted migration scenario among foresters was the role of climatic modelling. For instance, one forester referred to a unique Arctic air mass that significantly chills the Athabasca region and that there was skepticism of whether these finer scale weather patterns would be accurately captured and translated into provincial seed zones. In considering the assisted migration scenario, it was regarded with caution. Environmental participants acknowledged the potential need for changing the way forests are replanted, but were only receptive to assisted migration occurring in a constrained environment. One environmental participant cited the changing conditions for wine growers and how wineries are having to adapt by growing different varietals as a way of expressing acceptance for adaptation. The only truly negative comment made during the environmental focus group interview was about the people who are responsible for selection and what their interests are.

Community volunteer participants expressed reticent acceptance of the assisted migration-based strategy driven by the notion that, as the climate changes, there will be a need to seek out trees that are better adapted to the new conditions. However, this was countered with concern about what adaptation strategies, such as assisted migration, will allow humans to do. Specifically, they could facilitate a status quo of intensifying consumption, which then leads
to further human impacts on the climate and planet. Additionally, the notion that maintaining a strong forest sector leads to healthy communities was dismantled by participants as there is a trend in replacing human labour with machine labour.

In discussions around the use of genetic modification, there was one forester participant who viewed it as acceptable, citing that it could be beneficial for economic and environmental remediation reasons. There were specific concerns asserted by other forester participants about one of the main commercial tree species planted that is also the focus of a lot of breeding research: poplar (*Populus* spp.). Specifically, concerns arose from the inability to contain the species because of its natural tendency to vegetatively reproduce. The concept of genetic modification was perceived unanimously as unacceptable amongst environmental participants. There was concern about the ability to contain genetically modified seed and about the genes presently being used in agriculture (*e.g.* Roundup ready crops) and the potential for ecosystem level impacts. Community volunteer perceptions of the use genetic modification in forestry were unanimously negative, mainly out of concern that long-term research of impacts is lacking, which is important because of the long-lived nature of trees.

### 4.1.5 Aggregation of Question 1 Results

In summary, some interesting trends in perceived acceptability were observed in the Q sort results between social groups across the study (see Figure 4-13).
Figure 4-13: Perceived acceptance of the nine Q sort forest management scenarios as reported by social group, where the y-axis values denote the mean rating of perceived acceptability (1 = least acceptable; 2 = not very acceptable; 3 = indifferent; 4 = more acceptable; 5 most acceptable). AM refers to assisted migration and GM refers to genetic modification. Circles denote where ANOVA and Scheffé tests revealed significant differences (at alpha = 0.05) in the way that different focus groups perceived a given scenario. Notes indicate where the differences exist with Xf, Xe, and Xb denoting mean scores for Foresters, Environmentalists, and Business Community respectively.
Notably, forester participants across the study communities expressed the most extreme attitudes when considering local versus assisted migration-based strategies; local-based strategies were perceived as significantly more acceptable than the assisted migration based strategies. Environmental participants across the study communities expressed varying attitudes toward most of the Q sort scenarios, but the mixed species strategies were by far the most acceptable. The business owners displayed slight preference for local-based scenarios over the assisted migration scenarios.

In considering the qualitative results from the focus group interviews, a total of 13 themes emerged. These themes are listed in order of most referenced to least referenced in Table 4-5. A number of interesting trends emerged across the study in the way that themes informed perceptions toward the adaptation scenarios. For instance, regarding the local-based scenario, the top four themes that informed perceptions were: 1) nature knows best; 2) limits to scientific knowledge; 3) no need to adapt; and 4) resilience. In contrast, perceived acceptability of the second assisted migration-based scenario was informed by the following top four themes: 1) limits to scientific knowledge; 2) socio-economic; 3) need to adapt; and 4) resilience. Finally, perceptions of acceptability for the third GM-based scenario were shaped most by the following themes: 1) limits to scientific knowledge; 2) resilience; 3) tampering with nature; and 4) socio-economic resilience.

Tables 4-6, 4-7, and 4-8 summarize the most common themes associated with each of the three adaptation strategies. These tables also show if the theme was used to describe a positive, neutral, or negative reaction to a given scenario.
Table 4-5: Emergent themes derived from the qualitative focus group interviews.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Definition of Theme Used in Qualitative Analysis</th>
<th>Proportion of References Associated with Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits to scientific knowledge</td>
<td>The idea that “there are clear limits to how much science and experts know” (Sjöberg, 2001, p. 189).</td>
<td>23%</td>
</tr>
<tr>
<td>Resilience</td>
<td>The effect that management has on diversity at the genetic, species, and landscape scale.</td>
<td>14%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>The effect that management has on social and economic values that contribute to the community.</td>
<td>12%</td>
</tr>
<tr>
<td>Tampering with nature</td>
<td>The idea that the management technique is an “unnatural [and/or] immoral activity[?]” (Sjöberg, 2000, p. 353).</td>
<td>10%</td>
</tr>
<tr>
<td>Nature knows best</td>
<td>The idea that the best management is done by nature.</td>
<td>9%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>The idea that vested interests of decision makers can lead to suboptimal management.</td>
<td>8%</td>
</tr>
<tr>
<td>Need to adapt</td>
<td>The idea that climate change adaptation in management is necessary.</td>
<td>6%</td>
</tr>
<tr>
<td>No need to adapt</td>
<td>The idea that climate change adaptation in management is unnecessary.</td>
<td>5%</td>
</tr>
<tr>
<td>Trust in scientists</td>
<td>The idea that scientists are equipped with the knowledge to make the best decision regarding forest management.</td>
<td>5%</td>
</tr>
<tr>
<td>Inappropriate adaptation method</td>
<td>The idea that the management scenario under discussion is inappropriate or unnecessary for the local area.</td>
<td>3%</td>
</tr>
<tr>
<td>Delay adaptation</td>
<td>The idea that adaptation in forest management may need to take place but is not necessary yet.</td>
<td>2%</td>
</tr>
<tr>
<td>Misplaced effort</td>
<td>The idea that adaptation is a misplaced effort and that society should be focusing on mitigating the anthropogenic climate change.</td>
<td>2%</td>
</tr>
<tr>
<td>Solution to environmental problem</td>
<td>The idea that the management technique could help to mitigate a specific environmental problem.</td>
<td>1%</td>
</tr>
</tbody>
</table>

Table 4-6: Relative importance of themes in shaping perceptions toward the local-based adaptation scenario. References to themes are segmented by how they were used to describe a reaction to a scenario (positive, neutral, or negative reaction). Proportions of total number of references are also presented.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
<th>Total</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature knows best</td>
<td>14</td>
<td>3</td>
<td>2</td>
<td>19</td>
<td>31%</td>
</tr>
<tr>
<td>Limits to scientific knowledge</td>
<td>2</td>
<td>0</td>
<td>14</td>
<td>16</td>
<td>26%</td>
</tr>
<tr>
<td>No need to adapt</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>19%</td>
</tr>
<tr>
<td>Resilience</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>6%</td>
</tr>
<tr>
<td>Need to adapt</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>Misplaced effort</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Delay adaptation</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Trust in scientists</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>
Table 4-7: Relative importance of themes in shaping perceptions toward the assisted migration-based adaptation scenario. References to themes are segmented by how they were used to describe a reaction to a scenario (positive, neutral, or negative reaction). Proportions of total number of references are also presented.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
<th>Total</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits to scientific knowledge</td>
<td>0</td>
<td>7</td>
<td>21</td>
<td>28</td>
<td>27%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>15</td>
<td>15%</td>
</tr>
<tr>
<td>Need to adapt</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td>14</td>
<td>14%</td>
</tr>
<tr>
<td>Resilience</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>14</td>
<td>14%</td>
</tr>
<tr>
<td>Trust in scientists</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>7%</td>
</tr>
<tr>
<td>Nature knows best</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>6%</td>
</tr>
<tr>
<td>Delay adaptation</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Misplaced effort</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>No need to adapt</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Inappropriate adaptation method</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Tampering with nature</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 4-8: Relative importance of themes in shaping perceptions toward the GM-based adaptation scenario. References to themes are segmented by how they were used to describe a reaction to a scenario (positive, neutral, or negative reaction). Proportions of total number of references are also presented.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
<th>Total</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits to scientific knowledge</td>
<td>0</td>
<td>3</td>
<td>21</td>
<td>24</td>
<td>24%</td>
</tr>
<tr>
<td>Resilience</td>
<td>1</td>
<td>4</td>
<td>15</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>Tampering with nature</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>5</td>
<td>1</td>
<td>10</td>
<td>16</td>
<td>16%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>10</td>
<td>10%</td>
</tr>
<tr>
<td>Inappropriate adaptation method</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Trust in scientists</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Solution to environmental problem</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2%</td>
</tr>
</tbody>
</table>

Categorizing the emergent themes by social group allowed for a deeper understanding of the driving factors that shape the Q sort results observed in Figure 4-13. Table 4-9 summarizes the relative importance of the emergent themes in forming forester participants’ perceptions regarding all scenarios. Interestingly, the dominant themes informing perceived acceptability across scenarios for the participants in this social group were that there are perceived limits to scientific knowledge and the notion of resilience, which each explained 17% of the forester perceptions. Potentially as interesting is the second most dominant theme of there being no need to adapt practices, which represents 14% of the forester perceptions.
across the study. Additionally, 13% of the forester perceptions were explained by the theme of tampering with nature.

Table 4-9: Relative importance of the emergent themes in interviews with foresters across the study.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Proportion of References Associated with Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits to scientific knowledge</td>
<td>17%</td>
</tr>
<tr>
<td>Resilience</td>
<td>17%</td>
</tr>
<tr>
<td>No need to adapt</td>
<td>14%</td>
</tr>
<tr>
<td>Tampering with nature</td>
<td>13%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>10%</td>
</tr>
<tr>
<td>Trust in scientists</td>
<td>7%</td>
</tr>
<tr>
<td>Delay adaptation</td>
<td>6%</td>
</tr>
<tr>
<td>Inappropriate adaptation method</td>
<td>6%</td>
</tr>
<tr>
<td>Nature knows best</td>
<td>4%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>4%</td>
</tr>
<tr>
<td>Need to adapt</td>
<td>1%</td>
</tr>
<tr>
<td>Solution to environmental problem</td>
<td>1%</td>
</tr>
</tbody>
</table>

Table 4-10 summarizes the relative importance of the emergent themes in forming environmental participants' perceptions regarding all scenarios. The dominant theme informing environmental participants was the notion that there are perceived limits to the scientific knowledge, which explained 27% this social groups’ perceptions. 21% of environmental perceptions focused on how scenarios affected the resilience of the forest. A need to adapt and how the scenarios affect the socio-economic conditions for the community accounted for 12% and 11%, respectively.

Table 4-10: Relative importance of the emergent themes in interviews with environmentalists across the study.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Proportion of References Associated with Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits to scientific knowledge</td>
<td>27%</td>
</tr>
<tr>
<td>Resilience</td>
<td>21%</td>
</tr>
<tr>
<td>Need to adapt</td>
<td>12%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>11%</td>
</tr>
<tr>
<td>Tampering with nature</td>
<td>9%</td>
</tr>
<tr>
<td>Nature knows best</td>
<td>9%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>6%</td>
</tr>
</tbody>
</table>
Table 4-11 summarizes the relative importance of the emergent themes in forming business participants’ perceptions regarding all scenarios. Limits to scientific knowledge accounted for 23% of the business perceptions across the study. Another 20% of the perceptions in this social group were explained by the socio-economic theme. Additionally, 13% of the business participants’ perceptions were explained by the theme of nature knows best. Trust in institutions accounted for 10% of the business participants’ perceptions.

Table 4-11: Relative importance of the emergent themes in interviews with business across the study.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Proportion of References Associated with Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits to scientific knowledge</td>
<td>23%</td>
</tr>
<tr>
<td>Socio-economic</td>
<td>20%</td>
</tr>
<tr>
<td>Nature knows best</td>
<td>13%</td>
</tr>
<tr>
<td>Trust in institutions</td>
<td>10%</td>
</tr>
<tr>
<td>Tampering with nature</td>
<td>9%</td>
</tr>
<tr>
<td>Trust in scientists</td>
<td>7%</td>
</tr>
<tr>
<td>Misplaced effort</td>
<td>5%</td>
</tr>
<tr>
<td>Resilience</td>
<td>4%</td>
</tr>
<tr>
<td>Need to adapt</td>
<td>3%</td>
</tr>
<tr>
<td>No need to adapt</td>
<td>3%</td>
</tr>
<tr>
<td>Delay adaptation</td>
<td>2%</td>
</tr>
<tr>
<td>Inappropriate adaptation method</td>
<td>1%</td>
</tr>
</tbody>
</table>

4.2 Question 2 Results

In addressing the second research question, the role of Cultural Cognition of Risk was explored and, specifically, its role in influencing how perceived acceptability of forest adaptation strategies varied among participants in the study. The survey data collected during the focus groups was used to determine the cultural worldview of each participant. The results indicate
that 23 participants identified most strongly as hierarchists, 13 as hierarchical individualists, seven as individualists, and three as egalitarians (see Figure 4-14).

Figure 4-14: The distribution of study participants along Kahan’s (2012) group/grid cultural map, where each dot represents a participant.

To observe the distribution of cultural worldviews among study participants, frequencies of cultural worldview by community and social group were calculated. For simplicity’s sake, these frequencies were converted to percentages (Table 4-12 and Table 4-13 respectively).
Table 4-12: Proportion of participants from each community as classified by cultural worldview.

<table>
<thead>
<tr>
<th></th>
<th>Quesnel</th>
<th>Golden</th>
<th>Athabasca</th>
<th>High Level</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchist</td>
<td>39%</td>
<td>42%</td>
<td>54%</td>
<td>57%</td>
<td>46%</td>
</tr>
<tr>
<td>Hierarchical Individualist</td>
<td>28%</td>
<td>50%</td>
<td>8%</td>
<td>14%</td>
<td>26%</td>
</tr>
<tr>
<td>Individualist</td>
<td>28%</td>
<td>0%</td>
<td>8%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Egalitarian</td>
<td>0%</td>
<td>0%</td>
<td>15%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Unidentified</td>
<td>6%</td>
<td>8%</td>
<td>15%</td>
<td>0%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Table 4-13: Proportion of participants from each social group as classified by cultural worldview.

<table>
<thead>
<tr>
<th></th>
<th>Forestry</th>
<th>Business</th>
<th>Environmentalist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchist</td>
<td>25%</td>
<td>44%</td>
<td>67%</td>
</tr>
<tr>
<td>Hierarchical Individualist</td>
<td>25%</td>
<td>25%</td>
<td>28%</td>
</tr>
<tr>
<td>Individualist</td>
<td>19%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Egalitarian</td>
<td>19%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Unidentified</td>
<td>13%</td>
<td>6%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Interesting trends were observed regarding perceived acceptability of the adaptation scenarios (Figure 4-15). The limited number of egalitarians did not allow for an accurate comparison to the other three cultural groups and was, therefore, excluded from analysis. The most obvious distinction was observed between the individualists and the other two cultural groups (hierarchists and hierarchical individualists); namely, that perceived acceptability of the assisted migration-based scenarios was relatively lower among those who identified with the individualist worldview compared to those who ascribed to the hierarchist or hierarchical individualist worldviews. Consistent with individualist behaviours observed by cultural theorists, the participants that identified with individualism classified the most controversial scenarios that involve high risk and potentially high economic return as significantly more acceptable than the other two cultural groups.
Figure 4-15: Perceived acceptance of the nine Q sort forest management scenarios as reported by cultural group, where the y-axis values denote the mean rating of perceived acceptability (1 = least acceptable; 2 = not very acceptable; 3 = indifferent; 4 = more acceptable; 5 most acceptable). AM refers to assisted migration and GM refers to genetic modification. Circles denote where ANOVA and Scheffé tests revealed significant differences (at alpha = 0.05) in the way that different focus groups perceived a given scenario. Notes indicate where the differences exist with Xh and Xi denoting mean scores for Hierarchists and Individualists respectively.
Chapter 5  Discussion

A number of interesting findings emerged throughout this study that contribute to existing knowledge on risk perception, climate change adaptation, and societal perceptions of forest management in Western Canada. The following discussion is split into four major sections.

Section 5.1 addresses the findings from the first research question: How does perceived acceptability of a range of forest management climate change adaptation strategies and outcomes vary among forest-dependent community members? To frame this discussion in a manner that is most relevant to forest policy-makers, the following topics are addressed: 1) an overview of perceptions toward assisted migration-based forest adaptation strategies, with a particular focus on forester participant perceptions; 2) a discussion of how perceptions of adaptation strategies are affected by the degree of human intervention; 3) a discussion of how trends in social group perceptions toward adaptation strategies vary; and 4) a discussion of how trends in community perceptions toward adaptation strategies vary.

Section 5.2 discusses the results from the second research question: Can the cultural cognition of risk theory be used to explain the variation in public perceptions towards forest management climate change adaptation strategies? Results from this question are briefly summarized, and situated within the literature surrounding the theory of the cultural cognition of risk.

Section 5.3 outlines recommendations for policy makers relevant to the implementation of assisted migration in Western Canada, while Section 5.4 provides an overview of the limitations of this study.
5.1 Understanding what Drives Perceived Acceptability of the Interventions

This section discusses the results of Question 1 in the context of the literature. Section 5.1.1 provides an overview of the perceptions toward assisted migration-based strategies, as this is most relevant to policy-makers. A particular focus is given to forester perceptions as there were some unanticipated, and interesting trends in perceptions expressed in this social group. Section 5.1.2 discusses perceived acceptability in the through the lens of human intervention. Specifically, there is a discussion of how the phenomenon of how increasing human intervention is associated with decreasing perceived acceptability. Thresholds of acceptability are situated in the broader context of themes of confidence in science and decision makers, and the pressure to adapt to climate change. Section 5.1.3 and Section 5.1.4 discuss the variation in the results by social group, and case study community respectively. Specifically, the difference between forester and environmental participants is explored and the unexpected convergence in community-scale perceived acceptability is discussed.

5.1.1 Understanding Perceptions Toward Assisted Migration

The advantage of conducting qualitative focus group interviews compared to a more generalizable quantitative study is that a deeper understanding of the issues that inform acceptability can be discerned. In seeking ways to explain the variation in perceptions of assisted migration observed across this study, the dominant narratives that emerged must be considered. In the Q sorts, forester participants rated assisted migration-based forest adaptation strategies as relatively less acceptable than all other social groups. In the focus groups with foresters, the notion that there are limits to scientific knowledge emerged as a dominant narrative. Uncertainty regarding complex climatic modeling and the use of genomic knowledge
were frequently identified as components that increased the perceived risk of assisted migration adaptation techniques among all forester groups. Multiple explanations for these findings can be identified from the interviews.

Some participants indicated that the diversity present in local tree populations and species will allow local forests to be resilient and adapt as the climate changes. In regions such as Golden, where the mountainous topography supports high species and genetic diversity, this rationale is an understandable response. A desire to minimize the amount of human intervention on the forest landscape is an underlying driver of this perspective. Forester participants from this community were aware of past management regimes that, despite having been implemented with the best of intentions, resulted in further complications at the site level. Reference was made to the Forest Practices Code as a "cookbook" management regime that resulted in more problems than benefits for the heterogeneous region. Foresters from this region also mentioned conducting small scale experimentation, such as monitoring how western larch – a species that does not typically grow in the area – grows and interacts with the more conventionally planted species. In a recent study conducted by the Association of BC Forest Professionals (ABCFP) in 2013, 12% of BC RPFs reported that in addressing climate change they are experimenting with new techniques (Association of BC Forest Professionals, 2013).

To some extent, similar perceptions were noted amongst some of the Quesnel forester participants. However, their perceptions tended to focus on the mistakes made surrounding the planting of extensive single-age monocultures of lodgepole pine, which contributed to the unprecedented mountain pine beetle outbreak in Western Canada (Taylor & Carroll, 2003). Interestingly, despite the prevalence of literature linking warmer winters to pine beetle infestation, multiple forester participants in this case study community did not associate the
effects of pine beetle with climate change (Regniere et al., 2003). Instead, forest mismanagement and inappropriate fire suppression were identified as the most prominent causes of the pine beetle epidemic.

This indicates that perceptions of climate change adaptation are affected by additional factors beyond proximity to impacts. The foresters’ association of the pine beetle outbreak with poor forest management practices and their general refusal to acknowledge the role of climate change in the epidemic demonstrate that the notion of limits to scientific knowledge are of particular concern to the forestry community. Since the forest management techniques that precipitated the pine beetle outbreak were based on the latest science of the time, arguably leading to widespread environmental harm, it is understandable that the wisdom of scientific knowledge is in question. Considering that 83% of BC RPFs indicated that, “increased levels of natural disturbance/mortality due to insects and disease” (Association of BC Forest Professionals, 2013, p. 5) have been an observed impact of climate change, the views represented in some of the Quesnel focus group participants appear to be a minority.

Davidson et al. (2003) indicate that, “if people do not draw a causal connection between climate change and local consequences, then they may not perceive climate change as a risk issue and consequently may fail to assess and act on potential response options” (p. 2257). Indeed, this effect appeared to be prevalent amongst participants in the Quesnel forester group. Regarding adaptation, participants within this group were willing to incorporate greater local genetic diversity to enhance the resiliency of the local forests; however, they were largely unreceptive to the use of assisted migration at this time, as the climate necessary to support southerly genotypes has not yet materialized in their region, according to them. One possible explanation for this reticence resides in the high degree of forest-dependence that characterizes
Quesnel's economy: vast amounts of the pine forests in the TSA killed by mountain pine beetle place this town in very vulnerable position. As such, their hesitance to experiment with new techniques may be fuelled by a strong aversion to the risk of additional economic losses. There were comments made about the fact that there was likely at least one more rotation before techniques like assisted migration would need to be implemented.

This attitude of delaying adaptation was echoed amongst some of the forester participants in Athabasca, as well. Foresters here were somewhat skeptical that climate modeling at a provincial scale would accurately capture the nuanced climatic patterns that extend across the Athabasca FMA. A desire for finer-scale modeling is a natural response. In a way, this echoes the uneasiness observed amongst the forester participants in Golden who were uncomfortable with large-scale government interventions that might prove inappropriate at specific site-level management scales. In Athabasca, forester participants were relatively more receptive to the notion of assisted migration because of the current use of Region E spruce seed, which is bred for genetic gain and is approved for planting across a relatively large region in northern Alberta. Forester participants remarked on how coveted this seed was because of its robust genetic makeup; moreover, a greater trust in the science underlying assisted migration and the use of genomic information was facilitated based on an acknowledgement that the success of the Region E spruce seed is the result of a breeding project and human intervention. A commonly expressed viewpoint was that assisted migration, informed by genomics, would be an acceptable management tool within a broader portfolio of tools.

In interviews, Forester participants in High Level were also more accepting of the assisted migration-based scenarios compared to the BC forester groups interviewed, indicating
that as long as assisted migration policy was constrained to the population scale (vs. assisted species migration), it likely posed minimal risks.

Compared to the forester social group, environmental participants were, on average, more receptive to assisted migration-based strategies. A closer look at the dominant themes that emerged in environmental focus group interviews reveals that the perceptions of these participants were driven largely by concerns over genetic, stand level, and landscape resilience, the limits of scientific knowledge, and the need to adapt. This illustrates that there is an internal conflict ongoing between the need to adapt to climate change and the notion that humans continually make mistakes in environmental management even with the best of intentions and the most current knowledge being applied. This conflict echoes the ongoing debate amongst experts regarding the concept of assisted migration (Aubin et al., 2011).

As seen in the Q sorts, the least acceptable of the assisted migration-based adaptation strategies is the one that incorporated genomic knowledge. At first glance, this seems puzzling because this scenario provides the most certainty, at least from a scientific perspective. Based on the focus group interviews, however, it became clear that this sentiment did not arise from misperceptions pertaining to the nature of genomics; the Q sorts took place at the end of the interviews, and the definition of genomics in the context of assisted migration had already been clearly communicated to each of the participants. Rather, a possible explanation resides in the participants’ belief that, even though scientists have access to more data, there are limitations to scientist’s ability to interpret and draw "true" conclusions from large datasets. For instance, participants in Athabasca referenced the fact that imposing tree selection by way of genomics (or really even conventional tree breeding) could lead to the elimination of dormant genotypes that might be the key to growing in more arid climates.
Ultimately, many concerns were expressed during the environmental focus group interviews that reinforced the notion that there are limits to scientific knowledge. However, there were also almost as many comments made in reference to the need to adapt forest management practices in order to maintain this economically, culturally, and ecologically important resource. One component that seemed to greatly enhance the perceived acceptability of assisted migration was the incorporation of mixed species plantings. Resilience at the stand level (i.e. species mix) was especially emphasized in Quesnel in light of the mountain pine beetle outbreak. These perceptions can be explained by the participants’ desire to see greater diversity at the genetic, stand, and landscape scales as a result of their belief that this will lead to an increased resilience in forests to mitigate environmental change.

The business social groups in this study were selected to represent the proportion of the rural populations that did not necessarily have specialized knowledge in forestry or a vested interest in how forests are managed. Thus, it was interesting to see the how perceptions varied across this heterogeneous group. Generally speaking, they viewed assisted migration-based strategies with the most neutrality. As with the other groups, the notion that there are limits to scientific knowledge dominated any negative perceptions toward these strategies. However, a unique concern emerged from those who perceived assisted migration-based strategies negatively – the notion that adapting the forest is a misplaced effort. Participants who held this view determined that policy-makers should really be focusing on mitigating anthropogenic climate change instead.

Positive perceptions of assisted migration-based strategies across the study were driven by a perceived need to adapt to a changing climate. Generally, those who were receptive to this
set of strategies were supportive of it as one tool among many (less interventionist) adaptation tools that should be used in forest management during this era of change.

5.1.2 How do Perceptions Shift as the Level of Human Intervention is Intensified?

A variable that dictated a large part of the research design was the degree of human intervention required for an adaptation strategy. It was believed that a deeper discussion would be generated if the concept of assisted migration was situated within a set of possible forest management strategies and it was posited that contextualizing such management strategies along a spectrum of human interventions might generate interesting findings. In this way, participants were introduced first to conventional forms of forest management, as well as some more controversial forms of forest management and, subsequently, were able to think about the concept of assisted migration relative to these other management strategies. Specifically, in every aspect of this study, scenarios were designed on a spectrum of human intervention (see Table 5-1). This allowed for insight to be gained on the degree to which interventions affect perceived acceptability of forest management strategies.

Table 5-1: Forest management adaptation scenarios arranged on the spectrum of human intervention from no intervention to an extreme degree of intervention.

<table>
<thead>
<tr>
<th>No Intervention</th>
<th>Mild Intervention</th>
<th>Moderate Intervention</th>
<th>Extreme Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Regeneration</td>
<td>Three Local-Based Scenarios</td>
<td>Three Assisted Migration-Based Scenarios</td>
<td>Two Extreme Scenarios</td>
</tr>
</tbody>
</table>

The study revealed an observable trend that perceived acceptability of management strategies decrease as the degree of human intervention increases. For instance, local-based scenarios are relatively more acceptable than assisted migration-based scenarios. In seeking ways to explain this, it is important to consider the role of perceived uncertainty. Local-based seed transfer has been the dominant form of reforestation management since the 1940s, a practice to which the public is largely accustomed (Ying & Yanchuk, 2006). Through personal
experience or as a result of peripheral knowledge (e.g. gardening knowledge), most participants knew about regional seed zones and were comfortable with them.

There were also multiple references made to keeping the level of intervention as minimal as possible, which can be attributed to the idea that nature is the “best” manager of natural resources. According to Gobster (1992), public perceptions are often driven by aesthetics; therefore, practices that emulate the natural structure of the ecosystem are generally perceived as more acceptable by individuals who do not have working relationships with the forest. Another way in which aesthetics inform perceived acceptability is tied to the debate on mixed species vs. monocultures. It is thought that if the managed forest mirrors the aesthetic of wild forests – which have successfully self-managed for millennia – then the managed forest will be better equipped to adapt to abiotic and biotic changes. In regions where wild forests are composed of an array of different tree species – as is the case for much of BC and Alberta – then it is natural for people to prefer their adjacent managed forests to reflect such a mix. Thus, a diverse species mix is perceived as more acceptable and more resilient than monocultures (Fairweather & Swaffield, 2003).

As the level of intervention is scaled up to encompass assisted migration technology, perceived acceptability of the intervention falls dramatically. This can be attributed to Sjöberg’s (2001) theory that there are perceived limits to scientific knowledge. Incorporating plants from other locales into the local flora has a stigma associated with invasiveness and unanticipated ecosystem impacts (Aubin et al., 2011). Misperceptions initially amplified perceptions of risk. Specifically, participants in this study often immediately conflated the term assisted population migration with assisted species migration, which led to concerns that there would be unintended consequences of implementing assisted migration. Once it was clarified that the definition used
in this study was for assisted population migration, some of the perceptions of risk diminished, while many remained high, targeting instead the uncertainty around climate modeling and genomic knowledge. In fact, the Q sort scenario that featured assisted population migration based on climate modeling and knowledge of genomics was the least acceptable of the three assisted migration-based scenarios. This is initially puzzling, as this scenario utilizes the most knowledge and, thus, is the most informed assisted migration scenario from a scientific perspective. However, the other two scenarios appear less complicated in terms of the number of management components involved and are, subsequently, likely less alarming. Thus, participants’ relatively heightened risk perceptions toward the most complicated assisted migration-based scenario could be attributed to a perceived increase in human intervention (i.e. the incorporation of genomic knowledge into selection). If heightened human intervention is associated with heightened risk, than this would explain the aversion to this scenario. Another possible conclusion to draw from this is that the participants in the study were generally uncomfortable with the field of genomics, even in its less contentious forms (i.e. those that are not GM).

In considering the extreme forest management adaptation strategies of planting fast growing exotic species and employing genetic modification to achieve desirable traits, the theme that there are perceived limits to scientific knowledge became more prevalent as would be expected in the context of perceptions observed from the discussion of the other, less interventionist strategies. In the GM strategy, in particular, the theme of there being something morally wrong with tampering with genetic structures arose. This was distinct from perceptions associated with the genomic applications featured in assisted migration-based strategies. Sjöberg (2000) indicates that perceived risk can be significantly shaped by the notion that tampering with nature is inherently wrong and that only bad things can come from such follies.
This concept is deeply rooted in a moral sense of respect for nature and a belief that manipulating it is wrong (Hall, 2007).

Congruent with the above observations, respondents were often divided between those who felt there was no need to adapt to a changing climate and those that felt that there was. Notably, those who felt a need to adapt were more likely to rate assisted migration-based strategies as acceptable, despite having an awareness of the potential for unforeseen risks associated with assisted migration technology. However, the extreme forest management adaptation strategies seemed to exceed respondents' threshold of acceptable risk.

A denial of the need to adapt or a desire to delay adaptation can be classified as social limits to adaptation as these mentalities impede the uptake of adaptation strategies (Adger et al., 2008). Williamson et al. (2005) conducted a survey of members of forest dependent communities on the topics of climate change and forestry and inferred from the results that residents could be hesitant to “take action or [even] resist policies promoting adaptation” (p. 715). The findings from this thesis study show that there are a significant number of participants that could fall into this camp. Cultural worldviews do indeed appear to contribute greatly to the variation in perceived acceptability of the forest management adaptation strategies. This is discussed in greater detail in Section 5.2.

5.1.3 Variation in Social Groups

Another source of variation in perceived acceptability of the adaptation scenarios occurred between the social groups targeted in this study. The classic dichotomy is that of foresters as natural resource extractors and environmentalists as natural resource preservers. This dichotomy is more relevant to the BC region, as environmentalists tend to target the oil,
gas, and agricultural sectors instead in Alberta. Historically, the case that perhaps best illustrates the origins of this dichotomous relationship in forestry took place in the charismatic hyper-maritime forests of Clayoquot Sound. The summer of 1993 witnessed 10,000 protesters camping on a logging road to prevent harvest access to an old growth stand (Lavallee & Suedfeld, 1997). This blockade was coordinated with the launch of an international campaign against old growth harvesting that gained the support of “…more than 100 environmental groups [from] around the world” (Lavallee & Suedfeld, 1997, p. 197). Though not necessarily targeting individual workers, the Clayoquot Sound conflict pitted environmentalists and foresters against one another (Lavallee & Suedfeld, 1997).

Interestingly, evidence emerged in this study that the historical environmentalist-forester conflict has not diminished for some participants. In particular, certain forester participants commented that environmentalists cannot be trusted and that they have “glommed onto global warming”. This distrust may manifest in the lower levels of acceptability for assisted migration-based strategies. The concept of not wanting to “associat[e] with environmentalism” is also posited by Davidson et al. (2003, p. 2258) in seeking to explain perceptions of climate change risk among residents of forest-dependent communities. Indeed, some environmental participants indicated that forestry as a sector was “on its way out” and is no longer lucrative, trivializing the sector upon which their community is economically dependent. In many ways, this may inform the environmental participants’ relatively lower perceived acceptability toward assisted migration-based strategies that feature conventional timber species plantings, as many respondents did not see a need to maximize or even maintain timber profits.

In considering the business respondents, perceived acceptability toward the adaptation strategies tended to lie between the mean scores of forester and environmental participants.
This is understandable because there is likely less of a vested interest on how forests are managed among participants in this group.

### 5.1.4 Variation in Communities

Lastly, the multiple case design of this study facilitated the exploration of how adaptation strategies were perceived differently in different regions. It was expected that there might be some statistically significant variation across the study communities. However, when the Q sort means were segmented according to community, trends in perceived acceptability converged for all four communities. The only exception to this was in the case the assisted migration-based scenario that featured mixed species, as High Level participants deemed it significantly less acceptable than the other communities. High Level also deviated from the other communities in attitudes toward the GM adaptation strategy. Participants in this community perceived the GM strategy as relatively more acceptable than the other study communities. This could represent High Level’s priorities in maximizing economic return. High Level is a relatively young community, founded in 1965, to house workers in oil in gas industry (Government of Alberta, 2014). Because of its geographic remoteness, economic sustainability was a dominant concern for the majority of participants. This is reinforced by the notion that many residents do not settle in High Level for the long-term, which could reduce the sense of relationship and subsequent responsibility toward the landscape.

### 5.2 Understanding how Cultural Cognition of Risk Informs Perceived Acceptability of the Interventions

Recent studies continue to support the notion that the cultural cognition of risk (CCR) is an important component of perceptions, and is particularly relevant to climate change (Adger et
al., 2008; Braman et al., 2011; Kahan et al., 2011; Kahan, 2012). The results of this study indicate that CCR continues to play a role in determining how people respond to the risks of climate change adaptation even in applied contexts such as forestry. Specifically, it seems that individualist participants were less likely to perceive the assisted migration-based scenarios as acceptable compared to the hierarchist and hierarchical individualist participants. One potential explanation for this from the literature on cultural theory is that individualists are more inclined to dismiss environmental risks such as climate change and are, subsequently, more dismissive of adaptation strategies that represent making changes to management and could mean decreases in immediate economic returns (Douglas & Wildavsky, 1983). Presently, the use of local seed in BC and Alberta is profitable, so why would a new strategy need to be implemented unless it can achieve even higher profits? This supports Kahan et al.’s (2011) view that those with hierarchic or individualist worldviews are more likely to be “skeptical of environmental risks [because] widespread acceptance […] would justify restricting commerce and industry” (p.148).

In order to explain how hierarchists and individualists in the study diverged in perceived acceptability of assisted migration-based adaptation strategies, it is necessary to consider the national stance on climate change. Climate change is overtly referred to as an issue requiring immediate attention, with the “Government of Canada support[ing] an aggressive approach to climate change that achieves real environmental and economic benefits for all Canadians” (Government of Canada, 2013). As hierarchists place importance on protecting one’s social status within the hierarchy, it is logical to support adaptation strategies that governments endorse.

This logic holds true in considering the hierarchist participants’ perceived acceptability of the more extreme scenarios, which were deemed significantly less acceptable. Presently these
practices are tightly regulated on public lands, with only 0.02% of the BC AAC derived from exotic species and are presently not planted on crown land in Alberta – though there are no restrictions on private land (Alberta Forest Genetic Resources Council, 2001; BC Ministry of Forests Mines & Lands, 2010; Bonfils, 2006), thus, providing more evidence that hierarchists internalize what is deemed unacceptable by decision-makers and political leaders. In contrast, individualist participants’ rated these extreme scenarios as comparatively more acceptable in comparison to the other cultural groups. Proponents of both extreme scenarios highlight the potential for high economic returns (Alberta Forest Genetic Resources Council, 2001; BC Ministry of Forests Mines & Lands, 2010; Bonfils, 2006; Strauss et al., 2009; Walter, Fladung, & Boerjan, 2010), which is in line with the priority of achieving economic success, resulting in an “improved quality of life” (Kahan, 2012, p. 6). In assessing the potential risk associated with these adaptation scenarios, individualists are much more likely to consider nature as a benign entity and, therefore, associate a higher degree of intervention in natural landscapes with a lower level of risk (Thompson et al., 1990). Ultimately, using Kahan’s (2012) cultural cognition of risk theory to explain trends in perceived acceptability of applied climate change adaptation strategies in forest management indicates that cultural ideals did indeed effect how participants in the study perceived the risks of adaptation technologies.

5.3 Guidance for Policy Makers

In an effort to distil the findings from this study into cohesive and concise guidance points for policy makers, some suggestions for improving the uptake and acceptability of assisted migration and genomic applications in forestry are offered here. One of the most important conclusions to draw from this study is that, in considering the perceptions of participants regarding genomics-based forest management strategies, there generally seems to
be much uncertainty fuelled by the “newness” of this technology. Given time and longer-term studies on this subject, the perceived acceptability regarding the use of genomic information will likely increase. In the meantime, however, it may well be worth considering the creation of thoughtful outreach programs that demonstrate the benefits of utilizing genomic knowledge in tree selection which could lead to the additional benefit of broadening the public’s awareness of the different applications of biotechnology beyond its most controversial forms. It might also be beneficial to demonstrate how efforts to minimize risk are made with respect to genomic-based forest management strategies. For instance, these demonstrations could take the form of showing how more conventional and accepted tree breeding efforts will still be used and/or demonstrating a commitment to monitoring the field effects of trees that are selected using genomic methods over the long-term.

Results from this study could also be used to further the progress of assisted migration as a viable forest management practice. For instance, results showed that there was a tendency to conflate the terms “assisted population migration” and “assisted species migration”. Perhaps using different terminologies might inherently lower perceptions of risk toward this adaptation technique.

An additional consideration may be to better frame the need for assisted migration. For instance, it might be useful to address the need to incorporate a more diverse mix of provenances into plantings as a means of mitigating specific impacts (e.g. drought stress, insect infestation susceptibility). By framing the impetus for adapting forest management in this localized way, the polarizing concept of global climate change can potentially be sidestepped. Kahan (2013) has observed that this method of framing has been successful in regions in the United States where there are significant social barriers to climate change adaptation.
Another point to consider would be how to make outreach and information dissemination on assisted migration more effective. The findings from this study indicate that perceived risk of assisted migration is not driven purely by a knowledge deficit. It is evident that social circles and culture play a role in shaping perceptions of acceptability. For this reason, it is suggested that assisted migration as an adaptation strategy would best be communicated through accepted social and cultural networks. For instance, it may be beneficial to identify and highlight those foresters who are experimenting with assisted migration on small-scales as individuals who might be able to more effectively communicate to their peers. This could be done through culturally accepted modes of communications, such as newsletters and professional networking events.

Lastly, it is thought that increasing perceived acceptability amongst the non-forester social groups might be achieved through demonstrating a commitment to increasing mixed species plantings where possible. Similar methods of communication could be employed here, as well. For instance, it might be worthwhile to highlight well-regarded biologists and foresters in the area who are in support of experimenting with mixed species and assisted migration. In small towns, there are number of overlapping roles that people play in the community and, thus, it is not unlikely that there could be foresters or biologists working in the area that also hold respected cultural positions (e.g. local governments). Interviews on what these individuals are doing (e.g. what is working and what isn't) could be featured in local news outlets.

Ultimately, incorporating these and other social groups’ perceptions into the implementation plans for seed transfer policy will be critical to its success. Moving forward in this era of climate change, navigating social barriers to adaptation is just as complex and, at times, seemingly more complex than navigating the science.
5.4 Study Limitations

There were a number of limitations in this study. First and foremost, a critical social group was not included in the research design, namely First Nations. The primary reason for this revolved around the tight deadlines of the study and the need for relationship building to conduct meaningful and mutually beneficial research with First Nations. In terms of a path forward, in-depth consultation should take place with affected First Nations in Western Canada. Another limitation related to recruitment in the study communities. More established connections in some of the communities resulted in uneven recruitment. That said, effort was made to explicitly state these limitation in the results.

Two further limitations were in the focus group design were also identified. Firstly, the adaptation strategy visualizations were deemed too much of a distraction during the first round of focus groups and were subsequently not employed in the second round. Explicit effort was made to separate the attitudes expressed toward the visualizations from the attitudes expressed toward the actual scenarios. An additional inherent limitation in using focus groups as a method is that it introduces the potential for groupthink, where all participants end up providing the same generic response. Equally, another source of bias is present in focus groups because there is a chance certain opinionated individuals dominate the discussion (Stewart & Shamdasani, 2007). When this occurred, every effort was made, through facilitation, to minimize these biases and steer the direction of the discussions to be inclusive.

With regard to the quantitative exploration of how cultural cognition of risk shapes perceived acceptability to forest adaptation strategies, there were not enough egalitarians in the sample to provide meaningful results about this cultural worldview. This is likely a reflection of the rural study population. It would be interesting to see this study applied to a broader
population to determine whether further relationships between cultural worldview and perception of adaptation in forest management emerge.

Lastly, the qualitative nature of this mixed-methods study meant that the results are not generalizable to the population beyond the study sample. However, situating the more nuanced findings of this research within the context of other, more reductive quantitative studies – e.g. Hajjar et al. (2014, *In Press*) – serves to provide a robust view of the public perceptions toward the concepts of assisted migration and the use of genomics in forestry in BC and Alberta.
Chapter 6 Conclusion

During an era of rapid environmental change caused by the accumulation of greenhouse
gasses in the Earth’s atmosphere, society is under more pressure than ever before to mitigate
further climate change and adapt to the inevitable transition already set into motion. As such, a
number of novel adaptive natural resource management techniques are currently being
considered. For instance, the concept of assisted migration and increasing role of genomics in
forestry are presently under assessment for determining the technical feasibility of implementing
cclimate-based seed transfer policies and genomic-based seed selection. However, one of the
most significant factors that will influence the uptake of these techniques is societal perceptions
of these interventions.

The first objective of this study was to show how perceived acceptability toward a range
of forest management interventions aimed at adapting to climate change varied amongst
different social groups in forest-dependent communities of Western Canada. The second
objective of this research was to demonstrate how Kahan’s (2012) theory of cultural cognition of
risk (CCR) can help to shape perceptions of acceptability among the participants in the study.
Four communities (Golden and Quesnel, BC; and Athabasca and High Level, Alberta) were
visited and mixed method focus groups were conducted with foresters, environmentalists, and
business owners and managers from each of these towns in order to address these objectives.

A number of factors contributed to shaping perceived acceptability of forest adaptation
strategies among participants in this study. From the quantitative results, it was observed that
foresters perceived adaptation scenarios in a more extreme manner, rating local-based
scenarios that feature conventional timber species as relatively more acceptable than other
participants and rating the assisted migration-based strategies as relatively less acceptable. In exploring the qualitative findings to explain this, it was seen that many forester participants did not feel a need to adapt to climate change yet, or felt that they had tools necessary to adapt to any climatic changes with local seed stock. These heightened risk perceptions regarding assisted migration and the use of genomics to select trees can be attributed to the notion that there are perceived limits to scientific knowledge. This is understandable, given the grounded experiences that these individuals have with managing forests and the exposure to mistakes made in the past that were based on the latest science of the time. Foresters were, however, generally comfortable with increasing the diversity of local genotypes in plantings as a means of fortifying these ecosystems in the face of climatic change.

Environmental participants perceived the adaptation scenarios that featured mixed species as more acceptable than those that featured conventional timber species. The focus groups revealed that these participants were caught between concern about the effects of human intervention in forested ecosystems and the need to intervene in these natural systems in order to adapt to the impacts of global climate change. The preference for management techniques that incorporate more diverse species mix reinforced the priorities that many participants expressed in the interviews; namely, that incorporating resilience in the form of genetic, species, and landscape-scale diversity into management regimes (whatever this may entail) raises the perceived acceptability of techniques like assisted migration.

Business participants perceived the adaptation scenarios most neutrally, expressing a slight preference for scenarios that incorporated local seed sources. Participants from this group reinforced the theme that there are perceived limits to scientific knowledge (which emerged with the other two social groups). The second most common driver in perceptions was a concern
about how the socio-economic conditions in communities would be affected by implementing a change in management.

Interestingly, there was a convergence in perceived acceptability of the adaptation scenarios across communities. Only one significant difference in attitudes was observed where High Level participants rated the assisted migration scenario featuring mixed species and climatic modeling as significantly less acceptable than the Golden and Quesnel participants. This relative convergence is unexpected as one might expect regional identities to be more distinct. A conclusion to be drawn from this could be there is a need to engage with different social groups within communities on matters related to forest management, rather than approaching communities as a whole. This is due simply to there being diverse priorities and values present within each community.

To date, the debate on assisted migration and the use genomics in forestry has been restricted to expert circles (Aubin et al., 2011; Hagerman et al., 2010; Hall, 2007; Hewitt et al., 2011; McLachlan et al., 2007; Vitt et al., 2010). Through a layering of methods, this study sought to extend these debates to the public sphere. In doing so, it is hoped that policy-makers can make targeted and effective outreach programs, and that they also incorporate and address some of the relevant concerns expressed by participants in this study (e.g. the use of diverse species mixes) into policy where relevant.

Results from the second research objective indicate that culture shapes perceived acceptability toward the forest adaptation strategies among the participants in this study. For instance, participants that were classified as individualists perceived local-based strategies as relatively more acceptable than assisted migration-based strategies. This follows the priorities that cultural theorists have identified as unique to individualists (Douglas & Wildavsky, 1983;
In other words, the local-based strategies that are currently in place are economically viable whereas, experimenting with assisted migration may represent accepting an initial decrease in profits. For individualists, if a management technique cannot be economically justified, then there is no reason to invest. This logic holds true when considering the way in which individualist participants perceived the more extreme scenarios, which were rated significantly more acceptable than the other cultural types (hierarchists, hierarchical individuals). In this instance, proponents of both extreme scenarios often cited the potential for maximizing economic return. Unfortunately, due to the nature of the study population, there were not enough egalitarian participants to include this cultural type in the analysis.

CCR has been used extensively to study its effect in shaping risk perceptions toward climate change (Braman et al., 2011; Kahan et al., 2009; Kahan et al., 2011; Kahan, 2012). The results of this study add to the literature by showing that CCR continues to play a role in shaping perceptions among individuals as they are confronted with the risks of climate change adaptation strategies within a forestry context.

Looking forward, it would be interesting to undertake a larger-scale study of the influence of CCR on perceived acceptability of forest adaptation strategies. For instance, conducting this study across both urban and rural populations might increase the number of egalitarian respondents and, thus, elucidate even more interesting trends and deepen the understanding of how cultural worldview contributes to perceptions of risk. Additionally, it would be interesting to conduct a more in-depth longitudinal study of foresters perceptions over the coming decades as the climate and forests continue to change in order to study the way perceptions might shift in light of increased impacts on the landscape. Finally, meaningful participatory research needs to
take place with interested First Nations communities as the majority of the forests that would be affected by these policy changes are in Traditional Territories.

The incorporation of public input into forest management is a central tenet in modern natural resource management. During this period of rapid climatic change, the need to work with end users and communities is more critical than ever before, for it is through these individuals that actual meaningful change will take place on the ground.
References


BC Stats. (2012). *Community Facts, Quesnel, City* (p. 3). Victoria, BC.


References


### Appendix A: Data Sources for Ecosystem Visualizations

<table>
<thead>
<tr>
<th>Community</th>
<th>Scenario: Current (2012)</th>
<th>Scenario: Planting local selectively bred seed and natural regeneration (2080)</th>
<th>Scenario: Genomically informed assisted migration and natural regeneration (2080)</th>
<th>Scenario: Genetically engineered plantation (2080)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quesnel, BC</td>
<td><strong>Bioecoclimatic zone shown in viz:</strong> Sub Boreal Spruce – moist warm (SSBSmw)</td>
<td><strong>Dominant overstory species:</strong> 1) Douglas-fir; 2) hybrid white spruce; 3) subalpine fir</td>
<td>Stand less healthy and diverse than current condition, natural disturbance based on expert input (Simard, September 10, 2012; Carroll, September 4, 2012).</td>
<td>Plantations: 4 metre on-centre of lodgepole pine, based on expert input (Bonfils, 2006).</td>
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<tr>
<td></td>
<td><strong>Data source:</strong> Tongli Wang “var_obs” climate scenario</td>
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<td></td>
<td><strong>Data source for species mix:</strong> Del Meidinger and Jim Pojar (Eds). 1991. Forest Ecosystems of BC. Chapter 14: Sub-Boreal Spruce Zone by D. Meidinger, J. Pojar, and W.L. Harper, Figure 52, pg 214</td>
<td></td>
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<td></td>
<td><strong>Stand health</strong> (size, density, distribution, colour, presence of pests): as currently found in landscape.</td>
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<td></td>
<td><strong>Data sources:</strong> Height: Phil Grace’s species frequency and site index table; Density: Quesnel Timber Supply Area Timber Supply Review Data Package April, 2009, pg. 26; Colour and Appearances: Site photos from Google Earth Street View; Expert review by Ecologist Allan Carroll.</td>
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<tr>
<td>Golden, BC</td>
<td>Bioecoclimatic zone shown in viz: Interior Cedar Hemlock – moist cool (ICHmk); Interior Cedar Hemlock – moist warm (ICHmw); Engelmann Spruce Sub-Alpine Fir – dry cool (ESSdk)</td>
<td>Stand less healthy and diverse than current condition, natural disturbance based on expert input (Simard, September 10, 2012; Carroll, September 4, 2012).</td>
<td>Bioecoclimatic zone shown in viz: Interior Douglas-Fir - moist warm (IDFmw), Sub Boreal Spruce moist cool (SBSmk), Interior Cedar Hemlock – moist warm (ICHmw), Engelmann Spruce Sub-Alpine Fir – wet cold/dry cool/moist mild (ESSFwc/dk/mm)</td>
<td>Plantations: 4m on-centre of lodgepole pine, based on expert input (Bonfils, 2006).</td>
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<td></td>
<td>Dominant overstory species: 1) Douglas-fir; 2) lodgepole pine; 3) western red cedar; 4) western hemlock; 5) hybrid white spruce</td>
<td>Stand health (size, density, distribution, colour, presence of pests): as currently found in landscape.</td>
<td>Dominant overstory species: 1) Douglas-fir; 2) lodgepole pine; 3) subalpine fir; 4) western red cedar; 5) western hemlock; 6) hybrid white spruce</td>
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<td>Data sources: Height: Phil Grace’s species frequency and site index table; Density, colour and appearance: Site photos from Google Earth Street View; Expert review by Ecologist Allan Carol</td>
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**Appendices**
### Table

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<tr>
<th>Community</th>
<th>Scenario: Current (2012)</th>
<th>Scenario: Planting locally bred seed and natural regeneration (2080)</th>
<th>Scenario: Genetically informed assisted migration and natural regeneration (2080)</th>
<th>Scenario: Genetically engineered plantation (2080)</th>
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</thead>
<tbody>
<tr>
<td>High Level, AB</td>
<td>Species mix: Dry Mixedwood: Overstory: Aspen stands with scattered white spruce Central Mixedwood Overstory: Aspen, aspen-white spruce; white spruce – Balsam Fir (greater conifer presence and a larger array of moist-to wet communities such as tamarack, balsam poplar than Dry Mixedwood)</td>
<td>Stand less healthy and diverse than current condition, natural disturbance based on expert input (Simard, September 10, 2012; Carroll, September 4, 2012).</td>
<td>Species mix: Central Parkland: Plains rough fescue, western porcupine grass, slender wheat grass, Hooker's oatgrass, perennial herbs; Aspen, saskatoon, prickly rose, snowberry, beaked hazelnut, forbs Montane: Lodgepole pine, aspen or white spruce, hairy wild rye, Canada buffalo-berry, diverse forbs, feather mosses; Douglas fir also occurs north to Kootenay Plains and Jasper.</td>
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<td><strong>Stand health</strong> (size, density, distribution, colour, presence of pests): as currently found in landscape</td>
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<tr>
<td>Athabasca</td>
<td>Alberta Natural Sub Region shown in viz: Central Mixedwood</td>
<td>Stand less healthy and diverse than current condition, natural disturbance based on expert input (Simard, September 10, 2012; Carroll, September 4, 2012).</td>
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<td>Plantations: 4m on-centre of lodgepole pine distributed throughout central mixedwood / parkland subregions, based on expert input (Bonfils, 2006).</td>
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<td>Athabasca</td>
<td>Stand health (size, density, distribution, colour, presence of pests): as currently found in landscape</td>
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<td>Athabasca</td>
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Alberta Natural Sub Region shown in viz: Central Parkland migrates into region


Species mix: Central Parkland: Plains rough fescue, western porcupine grass, slender wheat grass, Hooker’s oatgrass, perennial herbs; Aspen, saskatoon, prickly rose, snowberry, beaked hazelnut, forbs

### Appendix B: Focus Group Interview Schedule

<table>
<thead>
<tr>
<th>Agenda Item</th>
<th>Objective(s) for Agenda Item</th>
<th>Format and Tasks</th>
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</thead>
</table>
| Arrivals, refreshments available | Informal gathering                                                                           | • Facilitator arrives early and checks room set up, logistics, etc.  
• Check on late-breaking news (no-shows, last minute issues surfacing, etc.)  
Participants begin to arrive                                                                                                                                                                                                                                                                                                                           |
| Administer entry survey      | Collect demographic and cultural worldview data                                               | Facilitator hands out entry survey that has a handful of demographic questions and a series of twelve Likert statements that are designed to identify the respondent’s cultural worldview                                                                                                                                                                                                                   |
| Welcome/Introductions        | To welcome participants to the focus group, set tone for meeting, and introduce everyone      | • Facilitator welcomes participants and offers introductory comments  
  o “I am really pleased you have taken the time to be here today”  
  o “The latest climate science is indicating that there will likely be some large scale changes occurring in the world’s forests. It is the purpose of this focus group to explore public awareness and perceptions on the different ways in which we might adapt our forest management during this time of change”  
  “Let us go around the room and introduce ourselves to the group by saying our name and affiliation”                                                                                                                                                                                                                                  |
| Overview of agenda           | To review the agenda                                                                         | • Part 1: Forest Values Brainstorm  
• Part 2: Climate Change and Forests  
• Part 3: Discussion of Adaptation Strategies  
Part 4: Q sorts: potentially make optional? Will go outside time… perhaps provide an incentive                                                                                                                                                                                                                                                          |
| Groundrules                 | To confirm shared expectations and shared norms for an effective meeting                   | • Facilitator comments on the importance of groundrules *(which will be posted on the wall)*  
• “With this in mind I have compiled a few things that can help us work together:  
  o One voice at a time  
  o Stick to the agenda  
  o Speak to be understood, listen to understand  
  o Speak to each other, not just to the front of the room  
  o Share opportunities for air time evenly  
  o Challenge ideas, not people  
“Are there any groundrules here that you do not support?”                                                                                                                                                                                                                                                                                                   |
| Forest values brainstorm     | To identify the values that participants derive from the local forests, identifying where there exist priorities | • Facilitator introduces brainstorming exercise that consists of asking participants to identify a couple of social, economic, and ecological values that Forest contribute to local area  
• Tack up papers to wall as arranged by economic, environmental, and social values  
“Rather than debriefing on these right now, I am going to ask that we move forward in the discussion and we will be returning to the results of this exercise during Part 3 of our discussion”                                                                                                                                                        |
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| Climate change and forests | To observe any existing awareness of climate change, observe if local disturbance events are attributable to global climate change, and provide info on the effects climate change has on the forest | • “Have you observed any changes on the local landscape that you attribute global climate change”  
• “Over very long periods of time, tree populations adapt to the local climate and soil conditions in which they grow. As the global climate continues to change, forests are expected to become poorly adapted to the areas in which they are growing presently. This means that they will grow less vigorously and be more vulnerable to insect and disease outbreaks”  
• Presents the Tongli/Hamann BEC climate consensus Projections at provincial and TSA/FMA scale (explains BEC and Alberta Natural Sub-regions)  
Uses this as a transition point to introduce adaptation scenarios |
| Refreshment Break   |                                                                                              | • Coffee/tea and crackers or cookies or some such are provided  
• Facilitator reviews the product of the discussion up to present and double checks that the projector is set up properly for the photo elicitation stage in the discussion |
| Adaptation scenarios | Introduce each adaptation scenario using the aid of visualizations, observing initial perceptions of acceptability/unacceptability, observing how they would affect the socio-economic conditions and the community and household levels, and eliciting final perceived acceptability for each scenario | • Facilitator hands out worksheets (Appendix B) to each participant and explains that she is most interested in hearing their initial perceptions regarding the acceptability of the scenario and that there will be space (in the worksheet) modify their initial judgment of acceptability and provide reasoning on why their perception shifted  
• Facilitator presents first visualization that represents the local forest ecosystem in 2080 where a particular adaptation management strategy has been implemented in the forest and the climate conditions have shifted to reflect projected conditions [only presented in BC communities]  
• “Please check whether or not you would accept such a scenario”  
• “Can you please explain any factors that contributed to your judgment?”  
  o Probe to understand what the driving force(s) behind acceptability is/are  
• “Reflecting on the forest values we discussed in the beginning of this meeting, would you expect to see any socio-economic changes as a result of changing management in this way?”  
• “Has your opinion on the acceptability of this scenario changed? Please indicate this on the worksheet and provide a brief explanation of what caused the shift”  
• This process is repeated for each of the three scenarios (which are summarized in Appendix A)  
• Worksheets are collected  
• “Do you trust the government to manage forests?” |
| Brain break          |                                                                                              | • Organize Q sorts.                                                                 |
| Conduct Q sorts      | To collect quantitative data on perceived acceptability of forest adaptation strategies      | • Describe the process of the Q sorting and provide an easy example  
• Set all participants up with the notecards and normal distribution mats |
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<tbody>
<tr>
<td>Concluding</td>
<td>To thank all of the participants for coming out</td>
<td>• &quot;I am deeply grateful for your participation in this project and hope that I have been able to provide you guys with an engaging evening”</td>
</tr>
<tr>
<td>remarks</td>
<td></td>
<td>• Indicate what actual management is, and what adaptation strategy is being pursued</td>
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<td>• This research is conducted with an earnest desire to make research that works for the end-user: you. “Be it if you are forester working directly with trees, or just enjoy the occasional hike, our existence is in various ways connected to this ecosystem and as it undergoes change, our lives change too.</td>
</tr>
</tbody>
</table>
