# Forest Values & Genomic Selection: Perspectives of Stakeholder Groups in Two West-Central Alberta Communities

by

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## Abstract

Forests face a variety of environmental and societal pressures and genomics offers one possible tool to help alleviate these pressures. However, public perceptions of genomic selection when used in tree breeding are not well understood. This study seeks to examine how stakeholders from forest dependent communities might interpret the implementation of genomic selection by relying upon risk perception theory. Specifically, some common themes and risk characteristics related to genomic applications in forestry are highlighted. Moreover, this study seeks to determine how individuals value forests and perceive current and future forest threats which can then inform how stakeholders view the necessity of management decisions such as the implementation of emergent technologies. As such, forest value literature is a focus of one chapter of this thesis. The results suggest that while different stakeholders can agree on the values that forests provide, how those values are perceived to be prioritized can result in disagreements. Forest management decisions seeking to address these multiple values are consequently difficult to agree upon due to subjective forest conditions or terms and in some cases a result of a lack of communication between stakeholders. Combined with skeptical climate change attitudes and conflicting ideas about disturbances resulted in further disagreement about management decisions. Pertaining to genomic selection, participants were wary, but rarely outright rejected genomic selection implementation. Primarily, genomic selection was viewed as uncertain with potentially unknown consequences. Participants were concerned how genomic selection would be used and in particular, how genetic diversity would be maintained. Some implications and suggestions about attempts to implement genomic selection in light of these stakeholder concerns are discussed.

## Preface

This thesis is an original work by Anthony Gus Fisher. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Forest Values & Preferences: An examination of Albertan Forestry Workers from Two Communities”, PRO00083831, October 2018-2019.

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# Chapter 1: Introduction

This introductory chapter serves to provide background about how this research is situated, gives a brief overview of tree breeding and genomic selection for those unfamiliar, and to provide context for the following chapters regarding the challenges that face forestry practitioners and some other forest users in Alberta. So, to address the first item on that list, I was fortunate enough to be assigned to a large scale applied research project supported by the funding agency of Genome Canada, as well as several additional funding providers, called Resilient Forests (RES-FOR) (for more information see: https://resfor.ualberta.ca/). Within that project was the smaller "genomics and its ethical, environmental, economic, legal, and social aspects" (see Genome Canada, n.d.) component, otherwise known as $GE^3LS$, of which I am a part. The team consists of various researchers, associates, and students from a variety of disciplinary fields (from economics, genetics, forestry and other natural sciences), as well as industry and government partners. The aims of the team included "integrat[ing] genomic, metabolomic and phenotypic data into selection models... These new integrated models will help us produce healthy, productive, and resilient forests while informing policy, determining the economic value of genomic selection and identifying social/political factors influencing the use of these cutting-edge selection strategies" (Resilient Forests [RES-FOR], 2019, para. 2). $GE^3LS$ research often seeks to bridge the technical science to those not within the technical areas of expertise. So, why study forests and forest related stakeholders, and what place does genomics have within forests?

Forests are intricate socio-ecological systems that hold vast importance for the environmental processes they maintain and for the people who rely upon them. At the same time forests are threatened by the many demands that are placed on them whether they be economic, environmental, or social (Messier *et al*., 2015). This creates a tenuous balance that is difficult to maintain, especially considering how climatic change will create unique and uncertain scenarios (Messier *et al*., 2015) with changes likely to be seen in disturbance regimes globally (Dale *et al*., 2001) and with climatic projections predicting forest ecosystem changes in Alberta (Schneider, Hamann, Farr, Wang, & Boutin, 2009; Stralberg *et al*., 2018). Planting forests under these various pressures becomes critical to help achieve sustainability goals (FAO, 2016) and to maintain human values. Currently, Alberta primarily reforests harvested stands through planting (Government of Alberta, 2015), with approximately 73% of all harvested areas being planted, mostly with conifers, while 26% of harvested areas are left to regenerate naturally. While these numbers certainly change every year, the benefits of planting over natural regeneration are many and can include: faster regeneration, the ability to select the best microsites in a stand for each seedling (Government of Alberta, 2015), and to better enable reforestation on sites that may otherwise be poorly suited for natural regeneration (Government of Alberta, 2017). For these and other reasons, the Government of Alberta (2015) has consistently reported that forestry companies have planted more land than was left to naturally regenerate at least since 2008 (likely longer, but this researcher did not find data prior to 2008). Planted forests, while certainly providing some advantages over natural regeneration, can only be so efficient. Thus, with increasing pressures and changing environments, rather than asking how reforestation should occur, an emerging emphasis (Nilausen, Gélinas, & Bull, 2016) and significant research (Neale & Kremer, 2011) has been focused on using insights from genomics to aid in selecting the stock to be planted, and how that selection may occur, based on the premise that such selection tools could offer benefits in the form of genetic gains, in growth in particular, that might not otherwise be realized.

Tree breeding is one way in which tree improvement can occur. Conventional tree breeding has been implemented in Alberta and across North America for many decades already, and programs are in place detailing how superior trees are selected, bred, tested, and propagated (see Namkoong, Kang, & Brouard, 1988; Zobel & Talbert, 1984). With the advent of biotechnologies, tools such as marker assisted selection and genomic selection have been suggested to aid or accelerate tree breeding efforts (for instance see: El-Kassaby, Isik, & Whetten, 2014; Ratcliffe *et al*., 2015). Genomic selection is of special interest as it is thought to better capture desirable traits (Meuwissen, Hayes, & Goddard, 2001) through a "genome-wide panel of markers… whose effects on the phenotype are estimated in a 'training' population" (Grattapaglia *et al*., 2018, p.3). That population is used to build a predictive model which can then be applied to selected individuals to determine the breeding values of those individuals (Grattapaglia, 2017). Genomic selection is also supposed to overcome some of the limitations associated with marker assisted selection; and compared to traditional tree breeding, genomic selection is thought to be faster for at least one generation of tree improvement (Ratcliffe *et al*., 2015). Indeed, Resende *et al*. (2012) propose that the use of genomic selection can drastically reduce the length of the breeding cycle and "virtually eliminate the long period of field testing" (p.618). Thus, the potential for genomic selection lies in reducing or eliminating the time-consuming process of phenotyping and replacing it with genotyping in selection for one or more generation(s) of breeding. There are also potential mitigative and adaptive benefits related to climate change. The higher growth rates and resulting increases in biomass potentially afforded via the information genomic selection may provide in selecting those desirable traits (Grattapaglia & Resende, 2011), may result in higher rates of carbon sequestration. Moreover, there is the possibility to breed and plant trees that are more resilient to climate driven biotic (Sniezko & Koch, 2017) and abiotic factors (Neale & Kremer, 2011). The outcomes of genomic selection nonetheless remain uncertain, and there may be sources of political and social reservation regarding these novel technologies that may not align with the scientific community.

Despite just recently being considered for forestry, genomic selection is not a new concept. It has been used in plant and animal breeding within the agricultural sector with success (for instance: García-Ruiz *et al*., 2016) with some saying it "has revolutionized dairy cattle breeding" (Wiggans, Cole, Hubbard, & Sonstegard, 2017, p.309). However, unlike agriculture, the use of genomic tools in Albertan forests poses unique challenges because forests exist on public land and therefore, can be a subject of greater scrutiny and concern. Other challenges exist such as the scientific and biological complexity of utilizing genomic tools on organisms that have both large genomes and long rotational times. Additionally, there is a noticeable lack of policy or regulatory framework that currently exists within Alberta specifically for the use of genomic selection in tree breeding. Nonetheless, the use of genomic selection in a forestry context has been met with a fair bit of enthusiasm from academia and other institutions. For instance, the authors of many academic papers have asserted that genomic selection represents or soon will represent a "paradigm shift" (p.116) in tree breeding (Resende *et al*., 2012).

It is disingenuous to presume this eagerness is unbridled as Sniezko and Koch (2017) emphasize; they would like to see models which are first validated before implementation, and there have been recognizable limitations, such as when considering the application of genomic models to different environments (Resende Jr *et al*., 2012). Direct mention of risks related to genomic selection are typically not explicitly stated in the expert literature, which more frequently refers to challenges. Primarily, there are concerns raised about model uncertainty and how to obtain the highest accuracy in genomic modelling. This is especially the case for forest genomics as “[n]aturally, the more factors are contributing to the system, the more complicated prediction of the response becomes, i.e., high uncertainty of the predicted gains” (Stejskal, Lstibůrek, Klápště, Čepl, & El-Kassaby, 2018, p.5). Hence, there is some recognition amongst experts about the complex nature of genomics. In addition, less accurate models may be developed depending on the size of the training population (Lenz *et al*., 2017) and the number of markers used in prediction (Isik, 2014). As well, depending on the trait of interest, the heritability of that trait (Grattapaglia, 2017; Isik, 2014) and trait architecture (Resende Jr *et al*., 2012) are not always well known and could also lead to models with lower accuracy. Furthermore, there are some authors who recognize the possibility of genomic selection resulting in inbreeding (Muranty *et al*., 2014) and a resulting reduction in genetic diversity (Grattapaglia, 2017), especially over a long period of time, but typically offer some options to control for this.

While experts may still be quite interested and enthusiastic about genomic selection overall, the potential remains for stakeholders beyond the community of experts to have concerns about genomic selection and its use within forestry. Identifying stakeholder concerns and recognizing potential differences between expert and lay perspectives are important. This is especially true for emerging technologies that have remained relatively out of public focus, but may quickly be seen as controversial. Messier *et al*. (2015) explain that involving stakeholders in forestry initiatives may prove as a basis for greater policy backing. Moreover, the inclusion of local community members is a key component of sustainable forest management (Jamal & Stronza, 2009).

## Research Objective & Questions

Genomics is a complex, multidimensional issue, especially when considering its implementation in forested environments. Discovering perspectives among publics regarding genomics is useful for predicting and explaining possible public backlash, but understanding those perspectives requires a broader look at forest values, perceived threats to those values, and the perceived appropriateness of different forms of management intervention. Thus, the objective of this study is to explore public perspectives about genomic selection, by focusing on a set of engaged forest stakeholders within Hinton and Whitecourt, two forestry dependent communities near central Alberta. Whitecourt is slightly northwest of Edmonton whereas Hinton is directly west. Both are within the Green Area of the province and Hinton in particular is located near Jasper National Park. A host of recreational opportunities and clubs exist within these areas. Moreover, both of these communities have a population of around ten thousand people and the average resident age is approximately 38 and 33 years for Hinton and Whitecourt, respectively (Statistics Canada, 2017). Natural Resources Canada (2018) find that the sensitivity of Hinton and Whitecourt to the forest industry economy are high and moderately-high for these communities and therefore, both communities are fairly dependent on forestry operations. In addition, two forestry companies near Hinton and Whitecourt, Hinton Wood Products and Blue Ridge Lumber, are invested in the RES-FOR project. As such, one reason for selecting these communities is to identify some common concerns in communities that are already interested in genomic selection.

This research is designed to assess the potential level of support or resistance among stakeholders to the adoption of genomic selection in tree breeding, by eliciting the personal views on forests, and to what extent genomic selection might be compatible with these views, among that segment of the population most likely to be actively engaged in public discussions of forest management: including individuals directly or formerly employed in the forest industry or government forest management, and leading figures in large recreational groups. To accomplish this, a few key research questions are asked. Chapter 2 addresses the first part of this research objective by exploring how management decisions can be informed by how engaged stakeholders value forests and their perception of various threats:

1. How do the engaged stakeholders in forest-based communities value forests?

2. What threats do participants perceive as affecting Albertan forests, and what do they think are the causes of these threats?

Accordingly, Chapter 3 seeks to answer the second part of the research objective by introducing stakeholders to genomic selection and asking their opinions about this technology.

1. What is the level of awareness of tree breeding efforts among engaged stakeholders?

2. What are the risks that various stakeholders associate with genomic selection application in forestry?

## Methods (Framework, Data Collection, Analysis)

Social scientists study perceptions and this study focuses on perceptions of genomic technologies. The initial proposal of this research sought to understand perceptions of genomic selection, but after the first few interviews it was quickly realized that risk perception would prove best to structure and analyze these interviews. Previous research utilizing the psychometric paradigm and biotechnologies proved useful and aspects of this paradigm were used to help develop themes in this study. Particularly, this paradigm is designed to inquire into how individuals, rather than groups (Goodfellow, Williams, & Azapagic, 2011), come to a decision about a hazard and how they subsequently act. Other risk theories, however, also helped to explain certain findings. Risk perception is essential in examining new technologies as a multitude of cultural, social, or psychological factors can help to explain variations in individual perceptions of a technology. Slovic's early work, such as Slovic (1987), on the psychometric paradigm, provides a useful framework for exploring how lay people interpret risks, by examining various risk characteristics associated with a hazard. This paradigm holds that risk has multiple dimensions, with unknown and dread being two primary risk characteristics. This provides one possible explanation between experts' and publics' perceptions of risk (Slovic, 1987; Hansen, Holm, Frewer, Robinson, & Sandøe, 2003). This study references risk perception work in multiple areas of study, including the agriculture sector, as risk perception studies of various biotechnologies is more prevalent there than in forestry. For instance, Sjöberg (2000) includes an additional risk dimension of (un)naturalness, which has been the focus of many studies of the adoption of agricultural technologies (see: Hansen *et al*., 2003; Frewer, Howard, & Shepherd, 1997). By examining the various characteristics that participants in this study attribute to genomic selection, a better understanding of how perceptions of genomic selection are divergent amongst proponents and stakeholders may be offered. In addition, some of the main points of conflict that may appear with implementation of this technology can be identified and possibly communicated before implementation occurs. Chapter 2 does not use a formal framework, but heavily relies upon forest value literature, climate skepticism, and some event attribution research.

A qualitative approach was determined to be most suitable for tackling the research objective and questions of this study. Maxwell (2013) comments that qualitative methods allow a flexible approach which is best used when “new discoveries or relationships” (p.30) need to be explored or when “[u]nderstanding the particular contexts within which the participants act, and the influence that this context has on their actions” (p.30). In this way, qualitative approaches are well-suited for this research as these methods allow for broad questions which can facilitate a back and forth discussion between the interviewer and the participant. This can result in qualitative methods eliciting more in-depth responses than what a survey would provide (Choy, 2014). This is especially important considering that there may be a lack of public awareness about genomics and subsequent questioning of genomic selection in forestry, which may require flexible, probing questions to attain meaningful responses. Quantitative methods, while useful to generalize the results of large sample sizes (Koerber & McMichael, 2008) or communities, does not, therefore, suit the purposes of this study; the qualitative methods utilized in this thesis are to highlight some themes and perspectives amongst stakeholders who are likely to be most personally familiar and aware of current forest management activities.

A research proposal was drafted and the methods detailed here were approved by the University of Alberta Research Ethics Board (PRO00083831). Data collection took place over a four-month period. Semi-structured, qualitative interviews were designed to reach research objectives. Interviews were conducted in person except in two instances where interviews were held over the phone. Interviews conducted in person were primarily in public locations such as coffee shops or restaurants, with only one interview taking place at a participant’s home. As well, all interviews were audio recorded with the exception of one instance. Twenty dollars was given as an incentive to recruit participants. An initial list of participants was provided by the Foothills Research Institute and through publicly available data. The first participants in the study were provincial employees working within the Forestry Division and more specifically, the Forest Management Branch (FMB). These Edmonton participants were contacted as they were presumed to not only offer valuable perspectives on genomic selection, but also have contacts within the two communities of interest; indeed, they did greatly expand the list of potential interviewees. In addition, the FMB staff were selected because of the implications of their work on present and future policy decisions and their knowledge of forest ecosystems. Participants in Hinton and Whitecourt were contacted next, after at least five potential contacts were identified. By continuing to use a snowball sampling technique, contact information for other participants in these communities was gathered after each subsequent interview. Hinton and Whitecourt were selected as they represent forest-dependent communities with many recreation opportunities and clubs. Both Blue Ridge Lumber and West Fraser Hinton are certified under the sustainable forestry initiative standard (Certification Canada, 2019). Moreover, both of these forest companies have already invested in genomic selection trials and thus, because of their vested interest in this technology it was deemed fruitful to determine initial stakeholder perceptions in these communities.

Individuals in these communities were contacted based on their work within the forestry sector or their involvement with a recreation group. As such, those who were most likely to be active in public discussions of management in forested environments were particularly sought after as they are the ones seeing and experiencing various forest conditions on a frequent basis, and are most likely to be engaged in shaping public views in their communities. Therefore, most of the individuals who were contacted are those already involved in forest politics and therefore, are likely to be most communicative when asked about new management strategies or technologies. In total, twenty-three participants were interviewed. Sixteen worked within the forestry sector and the remainder were part of recreation clubs. Four participants were from Edmonton, eight from Hinton and 11 from Whitecourt. Recreation users were members of the following: Whitecourt Trailblazers, Whitecourt Fish and Game Association, Hinton Mountain Bike Association, Hinton Nordic Ski Club, and the Hinton ATV Society. Other recreation groups were contacted, but did not express interest or simply did not respond. Data collection was discontinued as themes started to repeat and thematic saturation was reached towards the last few interviews with no new themes occurring.

The interview guide was created to facilitate discussion for one and a half hours. In actuality, interviews were typically around one hour, with the shortest interview being thirty-nine minutes and the longest being one hour and thirty-eight minutes. Questions asked remained the same regardless of stakeholder group, albeit with small alterations or omissions depending on relevancy of their occupation. The interview guide was divided into two different sections. The first entailed getting to know the participant and finding out how they utilized and appreciated forests, and to understand the various pressures that they believe forests face. As such, questions were related to attitudes towards management activities and natural disturbance events on the landscape. The second part of the interview guide focused on participants' awareness and relative knowledge of tree breeding and genomic selection. This involved asking about the usefulness of using each term in a forestry context. As well, a brief definition of genomic selection was provided, thus giving participants an opportunity to discuss what they think of genomic selection before and after information was given. The perceived negative consequences associated with implementing genomic selection were also explored.

Analysis began by transcribing all interviews. All transcription was done by hand. Interviews were written as recorded with pauses, laughter, or any other breaks in the audio noted. Quotes provided in the following chapters are kept with minimum alterations with only ellipses being used to improve the comprehension or certain words bolded to emphasize key points. These transcripts were anonymized and assigned a unique identifier. Memos were taken both during and immediately after interviews as well as when transcription was occurring. These memos often served as a basis for some initial, emerging themes and served to make connections with the literature. After transcription interviews were uploaded to NVivo 12 for Windows where interviews were assigned attributes based on sociodemographics. Coding began with Chapter 2 and Chapter 3 being coded differently. Chapter 2 and Chapter 3 both employ thematic analysis. However, Chapter 2 primarily focuses on organizational coding. Organizational codes were created based on stated (non)instrumental values, diverging opinions on management prescriptions, and grouping opinions based on each perceived threat or disturbance. On the other hand, Chapter 3 primarily uses theoretical thematic analysis. Maguire and Delahunt (2017) describe theoretical thematic analysis as "identify[ing] themes […] and us[ing] these themes to address the research or say something about an issue. This is much more than simply summarising the data; a good thematic analysis interprets and makes sense of it" (p.3353). Theoretical thematic analysis was used, based on the research questions of this study, to analyze particular parts of the transcripts. Coding was therefore based on theory related to 'dread' and 'unknown' risk characteristics, and within these categories more specific themes were identified related to risk characteristics unique to genomic selection. Codes were created, joined, and recreated as needed.

## Thesis Structure

Chapter 2 serves as an overview to how these communities depend on forests and demonstrates how participants think about forests and forest management decisions. Thus, this chapter primarily entails examining how people in forest dependent communities value their forests. These values are particularly highlighted under the context of recent disturbance events and climate change. A discussion about these values and perceptions of both natural and human altered disturbance on forest management decision-making, especially in terms of reception to management strategies, is explored. Chapter 3 introduces the same sample of individuals from Chapter 2 to tree breeding and genomic selection. Their awareness and relative knowledge of both of these terms were assessed. Moreover, the risks that they associated with those terms, especially genomic selection, was of interest. As Chapter 3 is largely a risk perception study it utilizes some aspects of Slovic's (1987) psychometric paradigm, but also makes reference to other risk perception theory. Chapter 4 will provide a brief conclusion summarizing the thesis, offering a few implications of the study, and indicating future avenues of research.

## Limitations

Finally, I fully acknowledge the many limitations of this study. While the study provides a large enough sample to develop initial themes and reach thematic saturation it cannot be considered sufficiently adequate to represent the views of the populations from which they are drawn. In particular, recreation stakeholders who had no associations with the forestry sector were not abundantly present in this study. This was partly due to difficulties in response rates and the nature of snowball sampling. For example, with snowball sampling it is typically more difficult to recruit individuals who have smaller networks and therefore, those with broader networks are typically most often sampled (Cohen & Arieli, 2011). As well, the sample was largely male, as forestry in Canada (see Reed, Scott, Natcher, & Johnston, 2014) and many recreation clubs in rural communities have been acknowledged as being male dominant and therefore, "women are faced with male occupational and organizational cultures that shape the extent to which women's participation is effective" (Reed & Varghese, 2007, p.517).

The intention of this study was not to be representative, but instead interview participants that are likely to hold strong opinions about how forests in Alberta are managed and be opinion leaders regarding forest management issues in their communities, including forest industry and government personnel. Those interviewed from recreation clubs were quite often people in positions of influence within these clubs and were those most active during club meetings and activities. Therefore, the individuals sampled were some of the more outspoken individuals in these recreation groups and therefore, they were often highly engaged about forest management decision making. Chapter 2 has limitations that are associated with most value and event attribution research. Firstly, while values were the primary focus of this chapter, the findings cannot explain or account for other variables such as trust or demographic characteristics that can be important for attitudes towards forest management. Secondly, not all values are easy to discuss, and the lack of expression of particular values or perceived threats could be an issue of interview fatigue rather than nonimportance.

While the results found in Chapter 3 are useful to determine some of the risk characteristics and overall perception towards genomic selection for stakeholders in forest-based communities, it does little to explain risks perceived by those in urban centers. As per cultural theory, individuals coming from different life experiences or cultural backgrounds are likely to perceive different risks. The risks presented in this study were also relatively devoid of social processes, albeit with the interviewer, and only serve as a quick 'snapshot' of some of the risks that subjects initially perceived. Social processes such as interactions between community members occurring on an everyday basis or more organized movements such as public protests can serve to heighten perceived risks (Kasperson *et al*., 1988). Additionally, a focus on this study was what risks are perceived rather than why they are perceived. Certainly, a few reasons why participants felt these risks were explored in this study, but can only be partially explained by the results. Moreover, since most participants were largely unfamiliar with genomic selection until being introduced to it in the course of the interview, their perspectives on this technology may not yet have been well-formed at the time of the study. It should also be noted that since the interviews conducted were with employees of forest companies that are already invested in genomic selection tests, awareness of genomic selection may be higher than expected compared to a community that had no invested interest.

## References

Certification Canada. (2019). *Forest Management Certification Canada 2018 Year-End Status Report Alberta*. Available from http://certificationcanada.org/en/statistics/provincial-statistics/. Accessed: January 14, 2020

Choy, L. T. (2014). The strengths and weaknesses of research methodology: comparison and complimentary between qualitative and quantitative approaches. *IOSR Journal of Humanities and Social Science*, *19*(4), 99-104. doi:10.9790/0837-194399104

Cohen, N., & Arieli, T. (2011). Field research in conflict environments: Methodological challenges and snowball sampling. *Journal of Peace Research, 48*(4), 423-435. doi:10.1177/0022343311405698

Dale, V. H., Joyce, L. A., McNulty, S., Neilson, R. P., Ayres, M. P., Flannigan, M. D., ... & Simberloff, D. (2001). Climate change and forest disturbances: climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. *BioScience*, *51*(9), 723-734. doi:10.1641/0006-3568(2001)051[0723:CCAFD]2.0.CO;2

El-Kassaby, Y. A., Isik, F., & Whetten, R. W. (2014). Modern advances in tree breeding. In Fenning, T. (Eds.) *Challenges and Opportunities for the World's Forests in the 21st Century* (pp. 441-459). doi:10.1007/978-94-007-7076-8_18

Food and Agriculture Organization of the United Nations (FAO). (2016). Planted Forests. Available from http://www.fao.org/forestry/plantedforests/en/. Accessed: June 1, 2019

Frewer, L. J., Howard, C., & Shepherd, R. (1997). Public concerns in the United Kingdom about general and specific applications of genetic engineering: Risk, benefit, and ethics. *Science, Technology, & Human Values*, *22*(1), 98-124. doi:10.1177/016224399702200105

García-Ruiz, A., Cole, J. B., VanRaden, P. M., Wiggans, G. R., Ruiz-López, F. J., & Van Tassell, C. P. (2016). Changes in genetic selection differentials and generation intervals in US Holstein dairy cattle as a result of genomic selection. *Proceedings of the National Academy of Sciences*, *113*(28), E3995-E4004. doi:10.1073/pnas.1519061113

Genome Canada. (n.d.). GE$^3$LS Research. Available from https://www.genomecanada.ca/en/programs/ge3ls-research. Accessed: September 8, 2019

Goodfellow, M. J., Williams, H. R., & Azapagic, A. (2011). Nuclear renaissance, public perception and design criteria: An exploratory review. *Energy Policy*, *39*(10), 6199-6210. doi:10.1016/j.enpol.2011.06.068

Government of Alberta. (2015). Sustainable Forest Management 2015 Facts & Statistics Sheets-Reforesting Harvested Areas. Available from https://www.alberta.ca/sustainable-forest-management-statistics.aspx. Accessed: June 3, 2019

Government of Alberta. (2017). Annual Status of Reforestation in Alberta Report 2016. Available from https://open.alberta.ca/publications/annual-status-of-reforestation-in-alberta-report#summary. Accessed: June 3, 2019

Grattapaglia, D. (2017). Status and perspectives of genomic selection in forest tree breeding. In Varshney, R.K., Roorkiwal, M., & Sorrells, M. E. (Eds.), *Genomic Selection for Crop Improvement: New Molecular Breeding Strategies for Crop Improvement* (pp. 199-249). doi:10.1007/978-3-319-63170-7_9

Grattapaglia, D., & Resende, M. D. (2011). Genomic selection in forest tree breeding. *Tree Genetics & Genomes*, *7*(2), 241-255. doi:10.1007/s11295-010-0328-4

Grattapaglia, D., Silva-Junior, O. B., Resende, R. T., Cappa, E. P., Müller, B. S., Tan, B., ... & El-Kassaby, Y. A. (2018). Quantitative genetics and genomics converge to accelerate forest tree breeding. *Frontiers in Plant Science*, *9*(1693), 1-10. doi:10.3389/fpls.2018.01693

Hansen, J., Holm, L., Frewer, L., Robinson, P., & Sandøe, P. (2003). Beyond the knowledge deficit: Recent research into lay and expert attitudes to food risks. *Appetite*, *41*(2), 111-121. doi:10.1016/S0195-6663(03)00079-5

Isik, F. (2014). Genomic selection in forest tree breeding: the concept and an outlook to the future. *New Forests, 45*(3), 379-401. doi:10.1007/s11056-014-9422-z

Jamal, T., & Stronza, A. (2009). Collaboration theory and tourism practice in protected areas: Stakeholders, structuring and sustainability. *Journal of Sustainable Tourism*, *17*(2), 169-189. doi:10.1080/09669580802495741

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., ... & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, *8*(2), 177-187. doi:10.1111/j.1539-6924.1988.tb01168.x

Koerber, A., & McMichael, L. (2008). Qualitative sampling methods: A primer for technical communicators. *Journal of Business and Technical Communication*, *22*(4), 454-473. doi:10.1177/1050651908320362

Lenz, P. R., Beaulieu, J., Mansfield, S. D., Clément, S., Desponts, M., & Bousquet, J. (2017). Factors affecting the accuracy of genomic selection for growth and wood quality traits in an advanced-breeding population of black spruce (Picea mariana). *BMC Genomics, 18*(1), 335. doi:10.1186/s12864-017-3715-5

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *AISHE-J: The All Ireland Journal of Teaching and Learning in Higher Education*, *9*(3), 3351-33514. Available from https://ojs.aishe.org/index.php/aishe-j/article/view/335. Accessed: September 3, 2019

Maxwell, J. A. (2013). *Qualitative research design: an interactive approach*. Third Edition. Thousand Oaks, CA: SAGE Publications.

Messier, C., Puettmann, K., Chazdon, R., Andersson, K. P., Angers, V. A., Brotons, L., ... & Levin, S. A. (2015). From management to stewardship: viewing forests as complex adaptive systems in an uncertain world. *Conservation Letters*, *8*(5), 368-377. doi:10.1111/conl.12156

Meuwissen, T.H., Hayes, B. J., & Goddard, M. E. (2001). Prediction of total genetic value using genome-wide dense marker maps. *Genetics*, *157*(4), 1819-1829. Available from https://www.genetics.org/content/157/4/1819. Accessed: June 20, 2019

Muranty, H., Jorge, V., Bastien, C., Lepoittevin, C., Bouffier, L., & Sanchez, L. (2014). Potential for marker-assisted selection for forest tree breeding: lessons from 20 years of MAS in crops. *Tree Genetics & Genomes, 10*(6), 1491-1510. doi:10.1007/s11295-014-0790-5

Namkoong, G., Kang, H. C., & Brouard, J. S. (1988). *Tree breeding: principles and strategies: principles and strategies*. doi:10.1007/978-1-4612-3892-8

Natural Resources Canada. (2018). Sensitivity of communities and regions to forest industry. Available from https://open.canada.ca/data/en/dataset/7e290b03-9555-4dd2-91be-d958136f11bb. Accessed: January 31, 2020

Neale, D. B., & Kremer, A. (2011). Forest tree genomics: growing resources and applications. *Nature Reviews Genetics*, *12*(2), 111-122. doi:10.1038/nrg2931

Nilausen, C., Gélinas, N., & Bull, G. (2016). Perceived acceptability of implementing marker-assisted selection in the forests of British Columbia. *Forests*, *7*(286), 1-19. doi:10.3390/f7110286

Ratcliffe, B., El-Dien, O. G., Klápště, J., Porth, I., Chen, C., Jaquish, B., & El-Kassaby, Y. A. (2015). A comparison of genomic selection models across time in interior spruce (Picea engelmannii× glauca) using unordered SNP imputation methods. *Heredity, 115*(6), 547-555. doi:10.5061/dryad.m4vh4.

Reed, M. G., Scott, A., Natcher, D., & Johnston, M. (2014). Linking gender, climate change, adaptive capacity, and forest-based communities in Canada. *Canadian Journal of Forest Research*, *44*(9), 995-1004. doi:10.1139/cjfr-2014-0174

Reed, M. G., & Varghese, J. (2007). Gender representation on Canadian forest sector advisory committees. *The Forestry Chronicle*, *83*(4), 515-525. doi:10.5558/tfc83515-4

Resende, M. D., Resende, M. F., Sansaloni, C. P., Petroli, C. D., Missiaggia, A. A., Aguiar, A. M., ... & Pappas, G. J. (2012). Genomic selection for growth and wood quality in Eucalyptus: capturing the missing heritability and accelerating breeding for complex traits in forest trees. *New Phytologist*, *194*(1), 116-128. doi:10.1111/j.1469-8137.2011.04038.x

Resende Jr, M. F. R., Munoz, P., Acosta, J. J., Peter, G. F., Davis, J. M., Grattapaglia, D., ... & Kirst, M. (2012). Accelerating the domestication of trees using genomic selection: accuracy of prediction models across ages and environments. *New Phytologist*, *193*(3), 617-624. doi:10.1111/j.1469-8137.2011.03895.x

Resilient Forests. (2019). RESFOR Home. Available from https://resfor.ualberta.ca/. Accessed: September 8, 2019

Schneider, R. R., Hamann, A., Farr, D., Wang, X., & Boutin, S. (2009). Potential effects of climate change on ecosystem distribution in Alberta. *Canadian Journal of Forest Research*, *39*(5), 1001-1010. doi:10.1139/X09-033

Sjöberg, L. (2000). Factors in risk perception. *Risk Analysis*, *20*(1), 1-12. doi:10.1111/0272-4332.00001

Slovic, P. (1987). Perception of risk. *Science*, *236*, 280-285. doi:10.1126/science.3563507

Sniezko, R. A., & Koch, J. (2017). Breeding trees resistant to insects and diseases: putting theory into application. *Biological Invasions*, *19*(11), 3377-3400. doi:10.1007/s10530-017-1482-5

Statistics Canada. (2017). Whitecourt [Population centre], Alberta and Hinton [Population centre], Alberta (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E. Accessed August 24, 2019

Stejskal, J., Lstibůrek, M., Klápště, J., Čepl, J., & El-Kassaby, Y. A. (2018). Effect of genomic prediction on response to selection in forest tree breeding. *Tree Genetics & Genomes, 14*(5), 1-9. doi:10.1007/s11295-018-1283-8

Stralberg, D., Wang, X., Parisien, M. A., Robinne, F. N., Sólymos, P., Mahon, C. L., ... & Bayne, E. M. (2018). Wildfire-mediated vegetation change in boreal forests of Alberta, Canada. *Ecosphere*, *9*(3), e02156. doi:10.1002/ecs2.2156

Wiggans, G. R., Cole, J. B., Hubbard, S. M., & Sonstegard, T. S. (2017). Genomic selection in dairy cattle: the USDA experience. *Annual Review of Animal Biosciences*, *5*, 309-327. doi:10.1146/annurev-animal-021815-111422

Zobel, B., & Talbert, J. (1984). *Applied Forest Tree Improvement*. John Wiley & Sons.

# Chapter 2: Juggling Values: Climate Change, Disturbances, and Management Decisions in Hinton and Whitecourt

## Introduction

Hinton and Whitecourt are two communities situated in west-central Alberta that have historically been exposed to, are currently experiencing to some degree, both the effects of mountain pine beetle and forest fires. They also espouse a host of instrumental and noninstrumental forest values. Forest-based communities are some of the most vulnerable to climate change (see Davidson, Williamson, & Parkins, 2003). Along with their close proximity to the forest and related disturbances, they are also heavily dependent upon the resource for their economy, and many community members "have strong ties to the surrounding landscape, and changes in this landscape may affect their activities and values" (Williamson *et al*., 2007, p.1). Hinton and Whitecourt present two such potentially vulnerable communities. Within these towns, recreationists, forestry workers, and a multitude of other users all coexist on the landscape. These forests are important for job security, economic prosperity, and support a way of life that these rural citizens have come to enjoy. Whitecourt has three Forest Management Agreements (FMAs) with large forestry companies, including pulp, paper, and saw mills. One of the larger FMA areas is licensed to Blue Ridge Lumber Inc. which covers just under 700,000 hectares (Government of Alberta, 2019). Historically, forestry in Whitecourt has been reported to generate over 500 million dollars in direct revenue yearly from 2005-2007 and employs 3,500 people (Alberta Forest Products Association [AFPA] & Alberta Sustainable Resourced Development [ASRD], 2008). West Fraser Hinton holds an FMA area of just under one million hectares (Government of Alberta, 2019) and contributes similar, but smaller employment and revenue numbers compared to Whitecourt (AFPA & ASRD, 2008). More recent data from Statistics Canada (2017) suggests 200 people in Whitecourt and 105 people in Hinton are both living in these communities and working in agriculture, forestry, fishing, or hunting industries, but this data does not include indirect or induced employment. In addition, these employment numbers are expected to be much higher if this included workers who live outside of these communities. Regional advisory groups are used in both of these FMA areas to involve the public.

This study looks to examine rural stakeholders as they offer insight into those who live, work, and recreate within the forests of these communities. Within these communities there are many such recreation stakeholders and several recreation groups. A few numerically identified participants help explain the relationship these clubs have with their communities. For example, one of the individuals interviewed in this study was a member of the Whitecourt Fish and Game Association, who stated: “I want to say, this year, we have about between seven- Usually between seven and nine hundred members. Um. Whitecourt is only, and I guess, and area is maybe ten thousand people. So. We have about 1[0]% of the population in our club (Interview 3.6).” The Whitecourt Trailblazers is a snowmobile club that is also a large recreation group, and another research participant (3.5) who was a member of this club estimated that they have about five hundred members. The recreation clubs sampled in Hinton seemed to be smaller, but still ranged from one hundred to several hundred members. One individual (1.7) of the Hinton Nordic club acknowledges their number of members is small, but also explains how the club impacts non-members as the club often volunteers to help run community held events. Suffice to say, recreation stakeholders are a large part of these communities. The impact of mountain pine beetle, fires, and the related adaptation strategies, such as prescribed burns, can significantly influence where, how frequently these members recreate, and the quality of their experiences on the landscape (see Bawa, 2017), which can potentially adversely affect the ongoing success of the club and the resulting community held events.

The present chapter explores how stakeholders value the forests surrounding their communities and offer some insight into how that could inform management decisions. Moreover, this study explores events such as wildfire and mountain pine beetle which are both climatically driven, but are also the result of social choices which have a very real impact on community and ecological stability. Carolan and Stuart (2016) comment that “[w]hile explanations of bark beetle outbreaks have tended to focus on biophysical drivers, the assemblages are more diverse than that. The bark beetle outbreak, while in possession of an ecological name, is a phenomenon with deeply social roots” (pp.84-85). So, while these events can certainly be threats to the many forest values that people hold, asking people what forces are driving these events is significant as well. Whether these events are viewed as human induced, or from climate change, reveals much about attitudes towards strategies attempted to adapt to climate change and associated disturbances. The perceptions of these, and other threats, form a major component of this chapter and serve as insights into how stakeholders might respond to management decisions, based on their conceptions of these threats. This study asks, how do these engaged stakeholders value forests? What threats do they perceive as affecting Alberta's forests, and what do they think are the sources of these threats? Finally, the study concludes with a discussion about the implications of values and perceptions on forest management decision making.

## Literature Review

Values, and more specifically forest values, have received their fair share of attention in scientific literature, principally because values are considered to be the foundation for other elements, like decisions and practices. The cognitive hierarchy, as demonstrated by Homer and Kahle (1988), is one framework which recognizes that the values that people hold are at the lowest level of cognition, which has a causal relationship with attitudes which in turn may influence behaviours. McFarlane and Boxall (2000) conducted a survey of two recreation groups in western Alberta and found that values do indeed correspond with attitudes towards forest management. While values are certainly important, however, there are other factors that can possibly impact attitudes (Homer & Kahle, 1988). For example, an individual's social group (see Beckley, Boxall, Just, & Wellstead, 1999) may influence what forestry activities they find more acceptable. While environmental valuation has attempted to assign dollar values to environmental amenities, given the many ethical, emotional, and intrinsic ties that people have, interpretative methods can better explain how people value environments (O'Brien, 2003).

A person's collection of values is referred to as their value orientation. The degree to which forest management is seen as sustainable is related to these orientations, such as those with biocentric orientations often find forestry less sustainable compared to anthropocentric leaning individuals (McFarlane & Hunt, 2006). Yaffee (1999) finds that even what ecosystem management entails is interpreted differently due in part to how anthropocentric or biocentric a person is in their orientation. Moreover, these societal value orientations can change (see Bengston, Webb, & Fan, 2004). Cubbage, Harou, and Sills, (2007) find that some societies have progressed to the extent of having forests that serve multiple purposes and a higher order of values beyond simple commodities. Accordingly, compared to historical management, current management has shifted and will continue to change to address changes in societal values. For instance, the movement away from sustained yield to sustainable forest management was a reflection of those changes in what a society values (Wang, 2004) although the two are not completely unrelated terms (see Luckert & Williamson, 2005). While societal values may be changing overall, differences in values that individuals hold can be divergent. Therefore, values can serve as a basis to understand how disagreements arise when it comes to forestry operations (Brown & Reed, 2000). Conflict can arise not just between people who hold different values, as is often the case between forestry companies and environmental groups, but those with similar values can also be prone to disagreement when certain values are given more importance over others (Dietz, Fitzgerald, & Shwom, 2005). Ives and Kendal (2014) give five reasons why values should be a priority when making management decisions: "(i) values change over time, (ii) values differ between groups of people, (iii) multiple values can be assigned to the same places, (iv) multiple pathways exist between values, attitudes and behaviours towards ecosystems and (v) values influence people's judgement of management decisions" (p.70). Thus, seeing that values are engrained in society and not necessarily stable across time, location, or across different stakeholders values need to be continuously assessed and considered when making decisions.

Values, while being a fairly abstract term, can be broken down into several categories. Firstly, values can either be held or assigned. Brown (1984) describes held values "as an enduring concept of the preferable which influences choice and action" (p.232). Alternatively, assigned values are used to make comparisons such as determining the "relative importance or worth" of one parcel of land over another (Brown, 1984, p.234) and thus, are more useful for understanding values at smaller scales (McIntyre, Moore, & Yuan, 2008). Further, within the category of held values, forest values have been typically divided into: (non)/instrumental, (non)/material, or biocentric/anthropocentric. Instrumental, material, and anthropocentric, while all slightly different, generally relate to how people use the forest whether that be for ecological, financial, or leisure use (Bengston, Webb, & Fan, 2004; Owen, Duinker, & Beckley, 2009). These groups also include the many ecosystem services (for example, see Oliver, Deal, Smith, Blahna, & Kline, 2016) that forests offer, with the exception of cultural services, which fall under the opposing categories. As such, noninstrumental, nonmaterial, and biocentric value systems refer to less tangible values, for example, aesthetic, spiritual, and cultural values (Tindall, 2003; Bengston *et al*., 2004; Díaz *et al*., 2015). These groupings form a basis on which many other values are characterised (for an overview of the values that old growth forests provide see: Moyer, Owen, & Duinker, 2008). Moreover, while these values are frequently categorized and many typologies have been attempted, Brown and Reed (2000) comment that forest values are not strictly separate, rather they are "interwoven" (p.247), and therefore the distinction between different values is not always clear.

A substantial body of research has focused on climate change attitudes. Political ideology (Dunlap & McCright, 2008) is one of the most significant factors influencing how people perceive climate change, along with various demographic characteristics such as gender and income (Semenza *et al*., 2008). Individuals with left-leaning ideologies have also been historically linked to more biocentric value orientations (Steel, List, & Shindler, 1994). One well studied example of political ideology on climate change attitudes the finding of a conservative white male effect, which explains how members of this one particular group are more likely than others to reject climate change in part due to existing power dynamics and related desire to maintain the existing economic order (see for example, McCright & Dunlap, 2011). Although, Driscoll (2019) finds that the importance of demographic characteristics may not be as predictive of attitudes towards climate change as it once was. The climate change debate amongst publics includes many forms of skepticism concerning the perceived causes and significance of changes in global temperatures. Rahmstorf (2004) creates three separate categories for climate skeptics: "trend", "attribution" and "impact"; those who disagree that global temperatures are becoming increasingly warmer, those who agree climate change is happening but not human caused, and those who agree climate change is human caused but will not create significant damage or would actually be advantageous. Skepticism implies some degree of uncertainty, unlike climate denial, which refers to great certainty. Dunlap (2013) describes a continuum from skepticism to denial, "with some individuals (and interest groups) holding a skeptical view of AGW [anthropocentric global warming] but remaining open to evidence, and others in complete denial mode, their minds made up" (p.693). While trend and attribution skepticism initially dominated narratives in print media, it has since shifted towards impact skepticism (Schmid-Petri, Adam, Schmucki, & Häussler, 2017). Therefore, more of the climate change debate has recently focused on questioning the damage climate change will cause and the resulting necessity of particular adaptation strategies rather than outright denial.

How people perceive climate change after extreme weather has also been a focus of study. Myers, Maibach, Roser-Renouf, Akerlof, and Leiserowitz, (2013) find that how people view climate change can be influenced by contact with climate-driven events. This is particularly important as this study examines stakeholders who are currently living in areas in which it is extremely likely for them to interact with mountain pine beetle and forest fires. Other studies have analyzed how flooding (Demski, Capstick, Pidgeon, Sposato, & Spence, 2017) can change an individual's perception and "leads to an overall increased salience of climate change…" (p.149). While communities may certainly experience these events, which may lead to greater confidence that climate change is happening, that does not necessarily mean all stakeholders perceive these events as climatically-driven despite frequent exposure. Indeed, Zanocco *et al.* (2018) determine that in their analysis of four communities, those who experience events that are quite severe and who already have great confidence that climate change is occurring are those most likely to associate fire events with climate change. Event attribution research has shortcomings, however, as "it remains unclear the extent to which this [disturbance events] may have effects at the population level" (p.50) and it is not known whether these disturbances have temporary or lasting effects on perception of climate change (Capstick, Whitmarsh, Poortinga, Pidgeon, & Upham, 2015).

## Methods

Semi-structured qualitative interviews were conducted with participants in Edmonton, Hinton, and Whitecourt. Participants in Edmonton were contacted as their work within the government has repercussions for forestry in both of these rural communities as well as province wide. Hinton and Whitecourt were selected as case study communities on the basis of being natural resource dependent communities, the recreation opportunities available there, and their proximity to both national and provincial parks. Individuals were contacted based on whether they work in the forestry sector (both government and industry) or were involved in a recreation group. These two groups were contacted because those involved with these two groups probably hold strong opinions on how forests are managed and are likely to want to participate in forest management decision making. The sample was also intended to include those who interact frequently within the forest (either professionally or recreationally). Stakeholders were selected via snowball sampling in which potential interviewees were first contacted through email. The use of snowball sampling is advantageous in that the connections between people allow researchers to access groups that are small or that are difficult to contact (Sudman & Kalton, 1986). An initial list of participants was gathered from the Foothills Research Institute. In addition, a few Government of Alberta employees with offices in Edmonton within the Agriculture and Forestry Ministry, and more specifically within the Forestry Division and the Forest Management Branch, but typically working in different sections were contacted. These individuals were contacted through email, which was available online. These participants greatly expanded the initial list of potential contacts in the Hinton and Whitecourt area. Twenty dollars was given as an incentive to participate. Participants were contacted until thematic saturation was reached. Interviews were audio recorded, except in one instance where just notes were taken. Additionally, interviews were conducted primarily in person except in two cases in which interviews were held over the phone. Each interview was transcribed and during transcription notes were taken to help establish key themes. After transcription, transcripts were imported into NVivo 12 and codes were created which formed the themes discussed in the results section. Each interview was assigned a unique number identifier. The methods described here was outlined in a research proposal and was approved by the University of Alberta Research Ethics Board (PRO00083831).

The final sample included 23 individuals: 16 currently working in the forestry sector, five who are involved in recreation groups, but have previous forestry experience (retired or switched careers), and finally, two individuals who had no forestry work experience, but were involved in recreation clubs. Those working in the forestry sector included, but were not limited to: ecologists, forest health officers, layout contractors, and foresters (assistant, planning, operations, silviculture). As a result of the snowball sample, some individuals had management roles, while others worked primarily in the field. The companies of Blue Ridge Lumber in Whitecourt and West Fraser in Hinton were the primary sources of respondents, with upper management often providing contact information for those who were not in a managerial role. From the areas of interest four participants came from Edmonton, 11 from Whitecourt, and eight from Hinton. The sample contained primarily middle-aged men with the majority of participants (16) falling between the ages of 40 and 60, three people older than 60, and four individuals younger than 40. Out of the 23 individuals, seven were women and 16 were men. Recreation users were members of the following: Whitecourt Trailblazers, Whitecourt Fish and Game Association, Hinton

Mountain Bike Association, Hinton Nordic Ski Club, and the Hinton ATV Society. Contacting other employees from other companies and recreationists from other clubs was attempted, but unsuccessful as no interested participants were heard from.

No single theoretical framework was used in this study, but is grounded within previous climate change skepticism research and forest value studies. The cognitive hierarchy was most notably held in mind during the initial proposal and draft of the interview guide. Nonetheless, there are underlying assumptions and expectations that must be stated as a portion of this study examines what was not said or readily dismissed. The study and questions asked were open and broad to allow participants to discuss what they felt was important. Topics discussed compared to topics avoided may not reveal differences in importance or significance, as interview fatigue may be a factor in some instances, but how pressing and visible these forestry related challenges are is implied by whether they are mentioned in discussion or not. For instance, if climate change was not mentioned in an interview that does not mean the participant did not think climate change was unimportant. Similarly, when it came to describing how they think forests are valued, the list is quite substantive and avoidance of a particular value should not indicate that an individual does not value the forest in that way. However, avoidance of a particular value or topic across the data set is suggestive of how some values/topics are more immediately appreciated or worrisome than others. There should also be recognition that nonmaterial values are more difficult to discuss than material values (Satterfield, Gregory, Klain, Roberts, & Chan, 2013). Attitudes and associations made or not made between fire, pine beetle, and climate change are expected to reveal preferences in how forests should be managed given the relative perception of these threats.

## Findings

### *Forest Values*

1. *Similarities in How Stakeholders Valued Forests*

Looking at how stakeholders value forests and the similarities amongst these values is useful to situate the sample, but does little to depict the importance of values on forest management decision making. This is because if all stakeholders valued forests similarly and agreed those values were adequately protected there would be no conflict between stakeholders.

Moreover, stakeholders may hold similar values, but by only looking at values, especially without context, no differences between stakeholders may be revealed when in fact there can be large differences in opinion about how those values are prioritized or achieved. Therefore, looking beyond values and closely examining scenarios in which some values are prioritized over others is warranted. Instrumental values were prominent in this study and there was a substantial list that was generated that includes recreation, economic (timber, employment, wood products, oil and gas) and ecological (diversity, complexity, water quality, wildlife habitat, sustenance) values. How forests contribute to air quality was mentioned fairly frequently, but direct mentions of carbon sequestration were less frequent. One of the few participants who mentioned carbon sequestration went on to say that "…one huge positive that I don't think the forest industry maybe advertises or talks about enough is just the amount of carbon sequestering that it does" (Forester, Whitecourt, 3.1). Several other participants directly related community stability and prosperity with the ongoing success of forestry operations in the area. For instance, a recreationist from Hinton (1.7) acknowledged that their community exists due in part to the forestry operations and the opportunities forests provide: "Like I'm only here because of the forest and there is, there is, a coal mining aspect to this community and there always has been. But generally, you know, I mean the forest is why we are all- why we are all here." Forestry was identified as critical to the establishment and ongoing success of these communities. As such, another participant recognized how businesses within the town were dependent on forestry:

> So, all of a sudden if you have to change the management of what the forest is and it affects the fiber supply to the mills then once that employment- there's going to be some employment impacts there and then those people- You basically have to leave town, um, cause you might right off the bat- Okay you find jobs here and there, but over time when you're kind of driven by the primary industry there's no other- All the other business in town is to support that. It's the gas stations and the clothes stores and everything. So, that all start to get impacts and they start to struggle more and it has that domino effect.
> ~Forester, Whitecourt (3.4)

Noninstrumental values were mentioned less frequently than instrumental values. Some participants recognized the difficulty of talking about this which often highlighted the intrinsic value of forests:

> It depends on what type of forest I'm in. Uh. I find around here there's a lot of opportunity to recreate in, not necessarily old growth forests, but intact forests. So, that's- It's kind of- I wouldn't call it a spiritual thing, but it's definitely, definitely, uh, a- Yea, I don't know how to put that in to words. ~Forestry worker, Hinton (1.8).

> Again, I look at my time in B.C. where I got to work in so many different forest types from cedar type forests to fir grassland types and the lodgepole pine plateaus and every forest has its own- They do actually have their own feeling. Um. You know you feel much different if you're standing in an old, closed canopy, wet, damp cedar hemlock forest with that thick moss layer and it's got a real damp strong groundy smell to it and if you're in a dry, grassland type- Like every forest has its own feeling about it. So, I don't know how to describe it, but it's a- hmm. I'm not sure how else to describe it. (3.1).

Aesthetic qualities were the most frequently mentioned noninstrumental value. Quite often sensory attributes of a forest were defining qualities. "It's humid. It smells like the forest. It smells like the earth and pine trees. And, uh, and a place where you're going to, you know, hear the wind moving through the trees and, you know, hear animals moving and, um, yea." (Government employee, Edmonton, 2.2). For some, these sensory experiences went as far as a personification of forests:

> I guess after spending so many years in it, not just as a forestry desk job, but actually spending years out in it for your daily living it's a little bit like home. You miss it when you are away from it. Um. It's comfortable to be back in it and it kind of has its own, in a sense, its own personality. Its own ways. ~Contractor, Whitecourt (3.7).

In addition to these sensory inputs a mental health component was acknowledged by some participants. One participant from Whitecourt (3.1) said "[t]here's just that spiritual grounding in nature when you're in forests and in nature. It's a reset. I find it recharging." Spiritual aspects of a forest such as the previous quote were occasionally mentioned, but not typically explained in depth. Surprisingly, mentions of maintaining forests for future generations did not come up often.

There were other noninstrumental values that revealed how access to the surrounding forests provided a certain quality of life for participants and their families. For example, "[b]eing able to have that experience on the landscape with your families is important to me especially in this day and age where everybody is so digital. Get my kids out and have them sleep in a tent. I like that" (Forester, Hinton, 1.2). Additionally, there were participants that touched on how forests are a key component to rural culture. For instance, a recreationist in Hinton (1.3) spoke of the benefit of living so close to the surrounding forests and being "[a]ble to get away from civilization. I'm not a city person at all. If I have to go into the city it's in and out. I'm not in there too long. I don't know, just freedom to use the areas. Go out to these lakes right out in the forest and treed areas and go for a drive. I'm always driving through the forest." Moreover, a forester from Hinton (1.8) stated how their career choice was dependent upon living in forest dependent communities and the people living there, as did other forestry workers:

> I chose forestry because I grew up in a community that had a large forestry based economy. Most of my, I guess I would call them, mentors worked in the forest industry. Um. And most of my friends' parents worked in the forest industry. So, that was what I was exposed to as a, as a, kid…

As such, participants represented moderate to somewhat more anthropocentrically orientated individuals and there was recognition that forests provide multiple values. Due to this it was unsurprising that no individual expressed a hands-off approach to successfully manage forests and there was broad agreement that harvesting forests certainly has a place on landscapes. The following quotes show motivations for accepting industrial activity on the landscape:

> Do nothing? Do nothing is good and I'm like no. I mean I don't agree with that. I think that's an ends to a means. Do we need protected spaces to enjoy? For sure, but do we have to also do things that influence the ecology of our forest that they regenerate and that we see, um, successive generations of forests that we enjoy? For sure. That requires intervention. That requires active management. ~Forester, Whitecourt (3.8)

> I also know that living here that it's, it's, a forestry based community. So, I see it as a potential for people to make a living so I don't deny that. We'll have something out there. It can grow. We can cut it down and it will grow again so we have something that is sustainable. That's important for me too to know that we, we- People can make a living

> off of something that is beautiful without totally destroying it if it's handled properly.
> ~Recreationist, Hinton (1.6)

These opinions were fairly consistent across the sample as there was agreement that forests need some type of disturbance and given the demands that humans have, offering a hands off approach is unrealistic. Of note, one individual in Whitecourt (3.7) identified the subjectivity of managing for a healthy forest and how current demands shaped acceptable management:

> Well, you know probably the healthiest of all forests is no longer with us. It's one that before we put hands on it. Hands off. It does what it does. […] There's value in young. There's value in old, but when we manage things and we decide the proportions of which that will remain on the landscape maybe that's healthy and maybe that's not healthy when we take the whole big picture in. You know? But, now it's managed. It's managed now, right, so we get to determine what's healthy for our management purposes. [...] Healthy I think is like beauty. It's in the eye of the beholder. It's in the values of the user.

Management must consider the plethora of values listed here or otherwise face disgruntled stakeholders by failing to properly sustain what forests mean for these individuals. While largely in agreement, to say that there were no differences or no contradictions in how people value forests would be inaccurate; disagreements did occur and this may be in part due to the aforementioned subjectivity. This becomes apparent when participants considered more specific management practices. A look into diverging values amongst stakeholders more adequately depicts why values must be considered when implementing a management strategy and are likely to determine reception.

2. *Differences in Values Revealed in Management Preferences*

At first glance participants seemed to value the forests around their communities quite similarly. However, participants' preferences for particular management strategies and their perspectives about current forest conditions revealed much about how individuals value forests differently and how they believe those values are best achieved. Multiple examples of disagreement surrounding management practices existed within the interviews and some of these are detailed throughout this document. Specifically, whether local forests are considered as adequately reaching a natural range of variation is a recurring theme in many sections below.

Moreover, while participants agreed forests should be harvested, there was contention about what that harvesting should look like and the goals of harvesting. As the above section details, participants largely agreed that forests hold economic, environmental, and social importance, but this did not account for how these categories are closely linked and how the emphasis of one category often comes to the detriment of another. One participant (1.2) acknowledged that "…it doesn't make any sense to not manage the resource in a way that it's going to be there for future generations. Just, business wise, it doesn't make good sense at all." Akin to sustained yield, this participant believed that by first focusing management on future economic value, social and ecological value would also follow. Others were less sure harvesting for economic value was the best way to ensure other values persist. For instance, one recreationist from Whitecourt (3.10) found that "[p]ublically, publically, owned forests are supposed to [be] a multi-use forest. They are not supposed to be just harvest[ing] the trees off it. It's supposed to be multi-use for the public. I'm not seeing a lot of emphasis put on that. It is basically log it off and make money." This individual was thus skeptical of whether the conventional sustained yield approach to management would sufficiently ensure values other than economic ones in their community. They emphasized that values other than economic values need to be given more priority to ensure forest management continues to provide those values. This is something that will be disucssed in later sections.

Differences between stakeholders when it came to valuing forests may be best examined through considerations of natural disturbance emulation. Current forest management has increasingly sought to emulate natural disturbance patterns to address historical mistakes of attempting to eliminate natural disturbances while still utilizing the forest for fibre. This is accomplished through harvesting patterns or prescribed burns that mimic ecological processes such as stand regeneration after fire. However, the participants in this study were divided, and questioned the ability of harvesting to successfully replace or replicate the values that natural disturbances create and hence, the ability of harvesting to maintain a forest's ecological function. For example, one proponent of emulating natural disturbances had the following to say:

> If you look at pictures of what the forest looked like around Hinton, you know, eighty years ago, it didn't look like this, and is that healthy? Maybe it is healthy in this snapshot in time, but that is what, if you are raised in Hinton, that is your vision of a healthy forest.

> And so, it makes it very difficult and very challenging to- for people to accept things like forest management on the landscape or allowing fire back on the landscape to change the demographic or the variability of the stands of trees in terms of age or species type if you have only for your short 40 years seen 80 years' worth of pine. And something that I talked to like the Robb community. They are very adamant that they don't want to see harvesting around their community and I've asked them if you look at pictures from Robb from the 1900's, the early 1900's, or if you talked to your grandparents did it look like it looks right now? And the answer is inevitably no. There was more range in age. There was more range in species. There was more diverse competition of the forest types and you don't get that without being able to manage the forest or allow wildfire on the landscape. And managing the forest is much less intrusive than allowing wildfire and it's more socially acceptable. ~Government employee, Hinton (1.5)

While this individual recognized wildfire as one possible option to properly sustain forest ecosystems, they argued that harvesting is the best option given the threat of uncontrolled wildfires. In addition, they advocated approaching management decisions in a longer, temporal scale than what others might use to judge current forest management activities. This example highlights how conflict can occur between communities and forest managers given different perceived value prioritizations, different ideas of what constitutes a diverse forest, and different temporal scales. Other participants seemed to have no particular preference towards disturbances used, but agreed that some form of disturbance had to occur. For instance, one participant (3.4) commented that the forest "has to have some mechanism of disturbance to kind of regenerate everything whether that is fires […]. Something. Even harvesting does that as well." In contrast, there were those who disputed the role harvesting has in replicating disturbance and, what will be discussed in depth in a latter section, argued that fibre and other values are perhaps outweighing what they believe forests should entail:

> Like making sure we put more wildfire back on the landscapes so that our boreal forest, you know, can burn as it should. I'm not hearing anything about that because of course we still are really focused on preserving the forest for timber values, oil and gas, those types of things. So, I think the economics of things are still getting in the way. (2.2).

Rather than emulating natural disturbance through harvesting this individual was clearly in favour of introducing more instances of wildfire on the landscape to achieve ecosystem values. Harvesting, for this individual, was not a means of achieving acceptable levels of environmental health. Others note that harvesting mimicking disturbance is possible and acceptable, but management activities have not yet reached an adequate level of emulation:

> So, when you look at when we harvest a stand of trees we tend to short cut nature. We still tend to cut relatively small patches and when you look at natural disturbance the natural disturbance regime within Alberta tends to see larger patches of forest being replaced by fire and that ecological process that it involves. And because of social issues we tend to keep our harvest areas relatively small and on average 21 hectares, but when you look at natural disturbance it tends to be significantly higher. Right? Or I should say there's a range, but nonetheless the majority of disturbance, the amount of area burnt, is within class E fires which is greater than 250 hectares, but some tend to be in the thousands or tens of thousands. Well, society is not okay with that and I think we have to continue to drive towards emulating our natural disturbance patterns which gives us greater flexibility on stand retention and managing the internal context of that area like natural fires do. When you have these little clearcut areas it becomes this microcosm of management strategies for this teeny weeny little- like a 21 hectare block is small relative to our natural disturbance thinking. (3.8).

> Well, like I said, that pure cut where you cut till you can't see a tree anymore. That's not right. They kind of say it's like a forest fire and I guess it is, but a forest fire doesn't burn- Like it'll leave clumps of trees not just a tree here and there so a bird can land to one to another to another. They have little clumps- There is a little bit of a diverse ecosystem where, um, they try to tell us that if we leave a tree here, a tree there, a tree here, well, at least a bird will have somewhere to fly and land to. Where is he going to live? You know? You need to make little clumps of trees in there […]. [I]t burns and it might leave a tree here and there, but it will also leave a clump of trees. It just goes right over top of them or it doesn't burn as hot in one little spot so the trees actually keep growing. It might burn the bark a little bit at the bottom of them, but they'll still grow. So, there's a little clump of old growth forest in that newly burnt forest that a bird or bear or whatever

> may have somewhere to go. I think they need to do that more instead of clearcutting everything. (3.6).

Both participants agree that emulating natural disturbances are some of the best actions to manage forest values and both argue that current attempts have yet to accurately represent natural disturbance patterns. However, they disagree about how fire actually behaves on the landscape and thus, have diverging opinions about the extent to which current management practices effectively emulate these disturbances. There was recognition that mimicking natural disturbances was one way in which economic, environmental, and other values could be more adequately managed. However, finding a balance between natural disturbances and human driven disturbance, even those that attempt to emulate natural disturbance patterns, poses a significant challenge and was a source of disagreement. The success and reception of particular management decisions is then in part determined by whether participants consider management actions as necessary and/or capable of emulating the values that natural disturbances maintain. However, disagreement will likely still arise given different ideas about how a fire or how other natural disturbances behave. The results here indicate that while participants may appear to value forests similarly, there is disagreement with respect to whether these values are being achieved, and the most appropriate means of achieving them. As people value forests differently, they have differing opinions on how to manage forests and thus, it is challenging to find agreement about the best course of action even amongst participants who agree harvesting can successfully mimic disturbance patterns.

*Perceived Threats to Forest Values*

The following sections revolve around disturbances on the landscape. Specifically, many interviewees mentioned that mountain pine beetle and fires present some of the biggest threats to forests and communities. A recreationist from Whitecourt (3.11) presents just one instance of how the potential effects of these disturbances on communities are perceived:

> Never used to worry about it, but since Slave Lake burned down … being in Whitecourt you know, having a major fire blow through at the wrong time just seems a way bigger risk than I thought it was. That’s one. Another risk. I feel like, uh, if something happens to the forest like pine beetle or huge- Like I don’t know how the forest industry works

completely, but if they run out of trees and mills and stuff, sort of shut down in these smaller towns then employees leave, property values plummet, investment in the area that people had goes in half. I feel like that is a risk now where I never used to think about that before.

However, that's not to say that disturbances were seen as unequivocally damaging as there was recognition, as seen in the above section with natural disturbance emulation, that disturbances are necessary on landscapes. As such, the sections below identify some key areas of agreement and contention about these disturbances. Examining differences in the role that participants believe disturbances should have on the landscape, along with their values, should also reveal preferences or perceived necessity of using particular management strategies, including those involving new breeding techniques.

1. *Prioritizing Harvesting over other Values*

When looking at harvesting and its corresponding trade-offs, stark differences in preferences amongst stakeholders were revealed. Disagreement when it came to pine beetle surge cuts and achieving a natural range of variation are two examples identified in this study of perspectives that question the role of harvesting on landscapes. The latter example is especially worth mentioning as it became a prominent point of discussion about how current levels of harvesting in the Whitecourt area are considered to be significantly impactful, and are a threat to snowmobiling activities. Two recreationists convey that other demands are perhaps unjustly outweighing both recreation and aesthetic values offered by older age stands. The first participant explains how high fibre demand might be the source of current forest conditions:

I: The scenic, beautiful, snowmobile trails are no longer scenic and beautiful because they are going through clearcuts. They've clearcut about every one of our trails. Seems like the last two or three years within a ten mile radius of Whitecourt is decimated. Clearcutting. It's almost like all the old growth trees have been focused on. I'm thinking because they are cheap with good road access and fibre's worth a lot right now and it's cheap to get it to the mill because it's close to town; but it's just decimated our trails through the forest.

A: So, that's something you disagree with when it comes to-

I:-The scale of it. The scale of it in the last few years. In the past they would do a couple of cutblocks and not a big deal. I grew up- The first cutblocks I saw when I moved here are now 20, 25 foot trees and they would only do one or two blocks each winter. Now it's devastation in my humble opinion. And I'm not against logging it's- keeps the, keeps the, wheels turning of the economy. Just the scale of it's almost unbelievable here (3.10).

The second recreationist conveys much of the same concern as the first as they see older pine stands disappearing in the area. However, they consider the possibility that current practices are not strictly related to fibre demand, but relate as well to how mountain pine beetle has influenced harvesting strategies:

I: There should be old growth forests that support, that support, the species that need thermal cover. You know their- Again, so you know that's going back to my trail experiences. Drive around our four hundred and fifty kilometers of trails and there's not one mature stand left. Not one. Right? So, that's a lot of landscape and there's been- Again, the harvesting activities from some of the companies have been- that's changed because of the pest because of the beetle because of where they want to go cut the beetle. So, now that the beetle cut is done now you go into other areas that might be, you know, say a higher spruce count. So, all of those spruce stands now- Like I said I'll challenge anybody to take you out and show you as much standing, uh, you know, large contiguous stands of standing spruce that support species that have to be in that forest cover. Right?

A: Right.

I: Right. So. So, is there forest out there? Sure, no question there is. Is the age class distribution right? It's not a question for me to answer. All I can tell you is that we can get on my snowmobile this afternoon and I'll take you for a long ride and you tell me how much you see. Is that just- Is that just one of those things that happens? Is it just random chance we didn't run over any big standing mature timber in the last four hundred kilometers? I'm not sure. Not a question for me to answer. It's a planning question (3.5).

For foresters in the Whitecourt area, while not directly mentioning the snowmobile issue, there were noted differences that became apparent when discussing a natural range of variation and how more removal, not less, will achieve that. For instance, when discussing the impact of fire on communities:

> …we'll continue to burn up communities and uh, and uh, lose infrastructure and potentially lose people. It can get pretty big and also lose the resource. So, whether that is- Again, it kinda gets back to how we either need to start using more fire on the landscape or harvesting or whatever it is. Um. It doesn't necessarily have to be just harvesting and just feeding saw mills, but we need to get back to a more natural range of variation out there. (3.1).

Using this individual's motivations, the cutting of older, mature stands in the Whitecourt area could then be possibly explained as an action long overdue, a return to a more 'natural' age class distribution through a reduction in older, mature stands, and an attempt to reduce the risk of fire to this community. Whether the actual decision to remove these specific stands that intersect snowmobile trails were for fibre demand, or pine beetle, or fire prevention goals is not clear and likely a combination of these goals is possible. However, this presents three separate opinions regarding harvest management objectives in the Whitecourt area, one for fibre, one for mountain pine beetle, and one for a more fire resilient community. Moreover, it illustrates how individuals have distinct differences when it comes to acceptable variations in age classes across a landscape. This reveals that some recreationists in Whitecourt certainly feel their values are not being taken seriously and, ultimately, shows a lack of communication between both recreationists and the forest industry at least for this particular issue. A clearer understanding of why the decision to remove older, mature trees from these highly valued areas needs to be conveyed to recreation stakeholders as they are unsure of why this is happening and consequently feel these management decisions are unjust.

2. *Past Management Decisions*

A recurring theme that was raised among participants was historic management activities. While typically identified as having good intentions at the time, they were seen by many as at least partially to blame for the frequency of disturbance events today. A number of participants referenced divergence from historical forest conditions to explain current frequency and severity of fire and pine beetle:

> I think the whole theme of what we've been talking about or what I've been talking about is the long term ramifications of, on the backend, and how often it takes us a long time for us to realize we've got a problem. Like let's stop fires on the landscape in the '60s and here we are in 2019 and we've got mountain pine beetle and mass fires. (1.5).

> I mean as soon as white men came to this country there was this need to supress wildfire which is not natural at all. And I think there is still a good portion of the population doesn't understand that. Like you know. I mean if you are not going to utilize the resource then it's going to burn, you know, and then you are going to put it out and then you are going to get mountain pine beetle. (1.7).

What makes these quotes intriguing is that they agree that suppressing disturbances on the landscape has led to extreme events, but disagree about the exact time in history in which people have strayed from maintaining healthy ecosystems. The latter example makes reference to natural forest conditions as being precolonial, while the former makes reference to mistakes made only in the last century. Comparing these two examples once again highlights differences in how people perceive stable or natural ecosystem conditions. Not all management decisions were confined to the distant past as fairly recent management strategies were also blamed for current natural disturbance events. For instance, one participant (1.2) acknowledged how recent mountain pine beetle attacks have been affected by what they perceive as the decision to do nothing in national parks and the resulting challenges that face their community and the forest industry because of that decision.

> I: Like have you ever driven to Jasper lately?

> A: Uh. It's been a couple months.

> I: Well, it is red as can be, right?

> A: Yea.

> I: Now we're- That's impacting us. And so, right now when we are thinking about our landscape here in Hinton we are thinking it is not really healthy. Stands are not really healthy. They have pine beetle spilling over like mad from Jasper and so that is also frustrating because Jasper chose to do nothing about it and consequently, is going to be

> impacting people's lives, communities, like, the forest. Right? Like it is going to have a huge impact. We are diligently trying to do all that we could here to lower- slow its spread and that's the government and ourselves. And the Feds are in Jasper. Didn't do a thing. So, that's frustrating.

This presents an instance in this study of how other values were seen as prioritized, such as recreation and aesthetic values, and outweighed preventative action such as the removal or harvesting of mature pine. Thus, this individual consequently perceived how inaction was detrimental to the continued spread of pine beetle.

The above quotations focus on fire suppression and not utilizing the forest for fibre which has led to older and therefore, more fuel laden stands, but in addition an increase in the wildland urban interface, and planting contiguous stands of pine were identified in the transcripts as also altering current disturbance events. Consequently, there was consensus on how past management decisions have altered natural disturbances and can negatively affect ecosystem stability. It should also be mentioned that while fires and mountain pine beetle were often presented as threats or problems, they were also seen, in some ways, as correctives: ecosystemic processes triggered by previous decisions and human activities that exacerbated conditions for disruptive events. Those disruptions, however, can constitute a source of renewal. One participant (1.3) identifies how previous mismanagement can result in disturbances that grant a fresh start:

> I know people in Jasper have packed up a lot of their, some of their, keepsakes and stuff they don't really need and stored it in storage units here because they're worried about Jasper burning up because the park didn't do anything about the pine beetle. So, you are driving to Jasper and it's just red. Everywhere you look is red. The next stage is black. The next stage is a goldy, orangey colour that comes along as nature resets everything.

This was something that was identified earlier with natural disturbance emulation. For some participants, specific types of management such as natural disturbance emulation helps to achieve the values that natural disturbances would otherwise accomplish. For others this was not the case. Overall, the individuals in this study frequently identified that disturbances are a threat, but also a necessity. Past management decisions were largely agreed to be a contributor to current wildfire and pine beetle attacks. At the same time, more recent management was seen as having the potential to either exacerbate these disturbances further or potentially reduce occurrences of these threats and help maintain ecosystem health. Therefore, participants had expressed complex views about disturbance; overharvesting or natural disturbances can be a threat, but too little disturbance was also seen as a problem. While the degree to which previous and current disturbance levels can be viewed as detrimental to the ecological health of the forest is an important question in the ecological sciences, participants assigned their assessments of 'too much' or 'too little' based on their values and experiences within forests. Public and stakeholder perceptions regarding the role of natural disturbances and harvesting in forest ecosystems remain crucial to their reception of different management strategies. This is especially true for management strategies designed for natural disturbance emulation, as this determines the extent to which people believe forest managers should intervene on the landscape, and which tools are deemed appropriate to do so.

3. *Climate Change Skepticism*

How climate change is perceived as impacting forests, particularly in the form of disturbances like pests and fire, is a key component to future forest management and reception to these strategies. Attitudes about climate change were quite varied within the sample. Four people within the sample did not mention climate change. While not mentioning climate change directly, one of those four participants did remark the weather has become more unpredictable as they find that "…the rain cycles are different too. […] We either don't get rain or we get a big excess of rain. It seems to be going that way. That's just kind of the way I'm seeing it" (3.10). The remaining nineteen participants attributed current and future forest conditions to climate change with varying degrees of importance and skepticism. A large number of participants conveyed that it was happening and that it posed a serious threat:

> But, I think a very significant change that's maybe, well, maybe overwhelm the human side is- Well, it is human caused too is the climate change aspect. And I think for Alberta probably more so than any other province in the country. […]And the modeling that we've done within the Alberta government and with our research partners at the UofA, um, show some pretty scary future scenarios about, you know, how much forest loss we can have with projected climate change within this century. ~Government employee, Edmonton (2.1).

So, we have a degree and a half change in our climate. What happens? Nothing? You know what happens to our snow belt and what happens to our ice cap? What happens to all those things? Most people say: well, I really like the nice winters. Great. You don't have to bundle up quite as often, but there's a huge impact on that. There's a huge impact on, on, on, you know what, on insects. Do the insects die off like they normally do? Do the pine beetles survive the winter? How do all those things affect, you know, what we as man are doing on the planet? (3.5).

As seen in the previous quote (3.5) participants who acknowledged that climate change was occurring were also likely to explain its contributions in terms of influencing forest fire and insect disturbance regimes. For the sake of brevity, here are just a few more instances of these realized associations:

If you, if you, look at beetle and what is causing beetle to be here where it has never been before it has got to be climate change. Like that's the only thing that makes any sense at all. Right? So, I think that- I mean I think our forests are changing because of climate change. I think we are seeing it right now, uh, with this mountain pine beetle because our winters are not getting cold enough to kill all the beetles. (1.2).

They planted some trees. Everything was hunky dory. A couple years later there was, um, a fire that came through and it took out all the trees that like ten years later after the trees had been planted. They are just getting up and going. They were all killed by a fire. Ok. So, then they go and replant for a second time and then, over the exact same piece of territory there was a hail storm that came through and nuked it all. Like literally killed mature trees which is pretty hard to do when you're a piece of hail, but it did it. It was that good of a storm. And so, again, all those trees were dead. So, there's a pretty concrete example about yea, climate change is changing. And then, what trees didn't get killed- after there was aspen defoliators that came through and was going to kill the rest of the aspen and then there was mountain pine beetle in the area as well. Armageddon. Right? ~Forester, Whitecourt (3.3).

Both of these examples recognize the multi-faceted issue of climate change and how an increase in temperature has repercussions on other aspects that further threaten the sustainability of forests. However, unlike the examples above, other participants in the sample were less certain that changes in climate were causing any differences within Albertan forests.

> I: And global warming, uh, I don't know. Is the boreal forest, you know, shrinking?
>
> A: You are not sure?
>
> I: Yea. (1.7).

Clearly, this participant was not confident that they have personally seen the effects yet. Accordingly, this individual realized fires and mountain pine beetle had recently caused great damage to Albertan forests, but did not attribute climate change as a contributor to these threats. Some participants made it known that they believed a change in climate was occurring and causing changes within forests, but was not a process influenced by humans:

> There's ice ages and there has always been this kind of global change of temperature which has affected what vegetation grows where on this planet. So, I definitely think that that is a natural change and those are- You also can't try and restrict when there's higher powers. If, if, the weather is changing that the forest will change accordingly. (3.4).

Another participant held a similar opinion that human agency plays a negligible role in climate change:

> A: Kind of moving on from that a little bit, uh, some scientists have suggested that Alberta's forests are changing. Do you agree with that and what do you think are the causes for that change?
>
> I: Pine beetle.
>
> A: Yea, pine beetle. Definitely changing the forest. Sure. And, yea, you did talk a lot about that already. Anything else that comes to mind? So, yea, you agree that it's changing?
>
> I: Oh, yea. Um. Are you thinking global warming or?
>
> A: If you think that's a cause of the change then-

> I:-I don't really believe in it. Things are getting warmer- I shouldn't say I don't believe in it. I don't believe that man has enough power to change things like they say we do.
>
> A: Right.
>
> I: One volcano does more damage than we can do in a thousand years. However, in Japan and places like that have a bazillion cars on the road and smog that is so bad, yea, we can change some things. Is it going to change global warming a whole bunch? No. I don't believe so. I mean it would be better for the environment if they tidied up the cars and made less pollution. That's why I live in the bush so I don't have to deal with that stuff. (1.3).

So, while they may see pine beetle as a damaging agent that affect the forests that they enjoy, they do not consider human caused climate change as affecting their lifestyle within the forests of Hinton. As such, the threat that climate change poses to forests for these individuals was often minimal or downplayed. Finally, one participant outright rejected climate change was occurring and causing change in forests. In their opinion, rather than posing negative consequences for forests, an increase in temperature would actually be beneficial:

> I don't know what exactly they [scientists] are saying the changes of it, but, um- If [mumbling]. If they are saying it's because of like greenhouse gases, well, I don't believe that either because more greenhouse gases you'd think there'd be more forests cause they suck that stuff up. (3.6).

The sample included a wide range of climate skeptics and while those who dismissed climate change were a minority in this sample, it stands out as a divisive issue. Moreover, as seen previously in this paper, while there was agreement that fire and mountain pine beetle can be significant factors, for some there was a disconnect between recent disturbances and climate change. That is to say, climate change was not always seen as a threat or something that humans contribute to and therefore, not something we have control over. For the respondents who did not mention anthropogenic climate change and for those who were unsure or dismissed its occurrence, what did they believe was causing an uptake in recent forest fires and mountain pine beetle events? One possible explanation is that they viewed these events as still being influenced by human actions, but just not through anthropogenic climate change. So, these events, which are observed to cause great damage and can be a threat to these communities, were often attributed to past management decisions, rather than climate change. While past management can play a role in disturbance events, whether individuals use previous forest management decisions to justify current disturbance events and hence refute or downplay the impacts of climate change needs further exploration. As such, management decisions that seek to directly address the threats of natural disturbances to forests and communities may have a greater amount of public approval than the same decisions under the guise of mitigating or adapting to climate change.

## Discussion

This paper sought to determine how stakeholders value forests and how that should inform management decisions. What was found was that participants in the sample generally agree on the broad social, environmental, and economic values that forests provide. Values are important to consider given that "[s]ustainability does not involve sustaining these three [(economic, social, and environmental)] as separate components. It involves coming to terms with trade-offs between values arising from our choices of management actions, or finding win–win solutions if possible, and recognizing the differences in values across individuals, regions, countries, and generations" (Adamowicz & Burton, 2003 p.46). However, this study also discovered that there was greater disagreement about how those values are best achieved and whether those values are currently adequately represented on landscapes even amongst a sample that is most accepting (large numbers of current or formerly employed forestry workers) of forest management operations. Jones, Shaw, Ross, Witt, and Pinner (2016) acknowledge that "…conflict between individuals or social groups with different sets of values, or different prioritizations of values, exploration and acknowledgement of these values can provide a basis for communication, stakeholder participation strategies, and design of more acceptable ways forward" (p.299). There were instances in this study where disagreement did occur due to these values seemingly not being properly addressed. In those instances, an individual's value system was important to understanding reception to particular management decisions. Ives and Kendal (2014) claim management that considers how others value forests can "…maximise the social acceptability of management actions and minimise potential conflict" (p.70) which can also potentially inform communication attempts between stakeholders. The results indicated a lack of communication in some instances that might explain how certain management actions are seen as attaining forest values by current forest managers, but not for recreationists. This is emphasized by the following individual (3.5):

> …outside looking in you're like man oh man why are you doing this? And then, cut all like a ten, twelve mile circle around Whitecourt, cut most of the standing mature timber that I know of. And again, they'd probably say there was a good reason for it. This was the reason. Right? Again, I don't know all the reasons.

Values also form a key component of forest management decision making as sustainable forest management (Adamowicz & Burton, 2003; Wang, 2004) and ecosystem based management (Canadian Boreal Forest Agreement [CBFA], 2015) all make reference to providing multiple or societal values. Ecosystem based management in particular utilizes a natural range of variation to achieve economic, social, as well as environmental values (CBFA, 2015). The failure to acknowledge and manage for these multiple values across various stakeholders has been a shortcoming of traditional forest management approaches (Lynam, De Jong, Sheil, Kusumanto, & Evans, 2007). This study finds that disagreement about a natural range of variation occurs in part due to the difficulty of defining what a natural range of variation looks like. For some participants certain actions were seen as attaining desirable forest conditions, while others disagreed that actions taken promoted sustainability in the forest or disagreed entirely with a specific method of management. Accordingly, meanings assigned to sustainable forests, healthy forests, a natural range of variation, and biodiversity were varied and likely due to these terms being "subjective" (Hull & Robertson, 2000, p.108) and vague even amongst foresters (Hull, Richert, Seekamp, Robertson, & Buhyoff, 2003). The study cannot conclude whether certain values were actually being prioritized over others, but for some individuals it certainly appears to be that way. Differing degrees of knowledge amongst different stakeholders may play a role in that subjectivity. Perhaps the most well-known instance of how knowledge and values can inform forest management decisions are attempts at incorporating traditional knowledge of Indigenous people (for instance, see O'Flaherty, Davidson-Hunt, & Manseau, 2008). Traditional ecological knowledge has been used across Canada and worldwide to increase Indigenous involvement in forest management, but also directly incorporate that knowledge into forest management plans such as "generating land use maps that incorporate spatial and temporal traditional uses" (Cheveau, Imbeau, Drapeau, & Bélanger, 2008, p.235). Subjectivity in management is not completely problematic as it does allow for more flexible management approaches, but it also creates more room for interpretation and resulting disagreement between stakeholders if collaborative efforts are not undertaken. Scientists use a variety of indicators or measurements to justify that forest values are adequately represented on a landscape, but these scientific based indicators may not match with public preferences (Failing & Gregory, 2003). The results demonstrate that since foresters typically have to consider more than just short-term landscape concerns and thus, have longer spatial and temporal considerations, disagreements may arise given that recreation stakeholders may have different or narrower perceptions of landscapes.

This paper also sought to examine how perceptions of threats might influence attitudes towards management decisions. Perceptions of disturbances are especially important given the interconnectedness between them and forest values (Hull *et al*., 2003; Allen *et al*., 2009). Compared to earlier studies that looked at various publics within western Canada (such as: McFarlane, Stumpf-Allen, & Watson, 2006) participants in this sample seemed quite aware and fairly knowledgeable about mountain pine beetle. While this study focused on different populations, the sample appeared to have expressed greater issue salience than found in previous studies as participants often explained its current spread and weather interactions (temperature on survival and wind on dispersal). In addition, the ways in which people interpreted disturbance revealed much about how stakeholders believed forest management operations should interject on landscapes. Fire and mountain pine beetle were often seen as both principle threats to forest values and necessary, natural processes for maintaining them. As such, relations with disturbance are intricate, but may represent shifting perceptions of disturbance especially in comparison to historical views about the purely catastrophic nature of fire (see Kauffman, 2004). The opinions presented towards emulating natural disturbances highlight how varied people's responses to disturbances can be. Moreover, management decisions must consider that "…forest adaptation to disturbances [i]s a dynamic process which involves the system's resilience and flexibility, not only from the ecological point of view but also from the social-economic one, i.e. concerning both the provision of forest goods and functions and the relation with society's value system." (Nocentini, Buttoud, Ciancio, & Corona, 2017, p.3). The stakeholders in this study did have varying perspectives about disturbances and this partially led to differing degrees of reception towards management decisions.

Attitudes towards climate change present an additional consideration when making management decisions. Climate change is especially problematic given that it is likely to exacerbate conflict as more difficult trade-offs and management decisions must be made. For instance, Keenan (2015) acknowledges that under climate change "[m]ore active management will be required if specific values are to be maintained" (p.160) and "…that we may not be able to maintain everything that forests have traditionally provided" (p.160). As such, the use of more management activities on a landscape presents one source of potential disagreement, but also the difficulty of accepting the disappearance of particular values can result in frustration for both forest managers and publics. Following Rahmstorf's (2004) skeptic categories, the participants in the study that were skeptical of climate change were mainly attribution and impact skeptics. Current forest management negotiates management outcomes with public interests, but some management strategies to address climate change may present challenges with providing both science driven management goals and socially desirable solutions (Kolström *et al*., 2011) and this is especially true given different degrees of climate skepticism. Finding a perfect balance between science and social acceptability cannot always nor should it always be achieved. However, under climate change forest managers face challenges in not only maintaining instrumental and noninstrumental values, but also deciding which values are a priority and accepting that not all values can necessarily be managed to the same degree. Greater collaborative and communicative efforts between stakeholders are needed to identify which values should be a priority and help come to terms with the realities of climate change in Alberta's boreal forest.

## Conclusion

Climate change has potentially large consequences for the ongoing success of the communities of Hinton and Whitecourt. Yet, community members disagree about its full implications especially in regards to disturbance events. While many participants in the sample attributed recent fire and pine beetle events as partially driven by anthropocentric climate change, there was still a small group that perceived human caused climate change as not happening or at least not affecting them significantly. This was compounded by how recreationists and foresters within these communities have disagreements about particular management activities and the role of disturbance on the landscape. The results in this study show one example of how different individuals prioritize or are perceived to prioritize some values over others in the case of snowmobiling in Whitecourt which is creating conflict. Some of this conflict may be generated by subjective terms, such as a natural range of variation, to express these values. A lack of communication is also likely to blame for some instances where stakeholders identified not knowing why certain management decisions were made. Overall, the forests of these communities were broadly valued for their economic, recreation, ecological, and intrinsic worth. Juggling these various values, differences of perspectives, and while facing the realities of climate change and disturbance events poses some of the most difficult hurdles these communities and the forest industry will face when making future forest management decisions.

## References


Adamowicz, W.L., and Burton, P.J. (2003). Sustainability and sustainable forest management. Chapter 2. In P.J. Burton, C. Messier, D.W. Smith, and W.L. Adamowicz (Eds.), *Towards Sustainable Management of the Boreal Forest* (pp.41-64). doi:10.1139/9780660187624

Alberta Forest Products Association and Alberta Sustainable Resource Development. (2008). *Economic impact of the Alberta forest industry*. Available from: http://www.assembly.ab.ca/lao/library/egovdocs/2008/alsrd/167559.pdf. Accessed: September 15, 2019

Allen, S. D., Wickwar, D. A., Clark, F. P., Dow, R. R., Potts, R., & Snyder, S. A. (2009). *Values, beliefs, and attitudes technical guide for Forest Service land and resource management, planning, and decision-making*. doi:10.2737/PNW-GTR-788

Bawa, R. S. (2017). Effects of wildfire on the value of recreation in western North America. *Journal of Sustainable Forestry*, *36*(1), 1-17. doi:10.1080/10549811.2016.1233503

Beckley, T. M., Boxall, P. C., Just, L. K., & Wellstead, A. M. (1999). Forest stakeholder attitudes and values: selected social-science contributions. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Available from: http://publications.gc.ca/site/archivee-archived.html?url=http://publications.gc.ca/collections/Collection/Fo46-12-362E.pdf. Accessed: August, 20, 2019

Bengston, D. N., Webb, T. J., & Fan, D. P. (2004). Shifting forest value orientations in the United States, 1980-2001: A computer content analysis. *Environmental Values*, *13*(3), 373-392. doi:10.3197/0963271041159804

Brown, T. C. (1984). The concept of value in resource allocation. *Land Economics*, *60*(3), 231-246. doi:10.2307/3146184

Brown, G., & Reed, P. (2000). Validation of a forest values typology for use in national forest planning. *Forest Science*, *46*(2), 240-247. doi:10.1093/forestscience/46.2.240

The Canadian Boreal Forest Agreement. (2015). Towards a Natural Range of Variation (NRV) Strategy for the Canadian Boreal Forest Agreement - Summary Report. 1-15. Available from https://www.fpac.ca/innovative-new-commitment-to-natural-landscapes-in-canadian-boreal-forest/ Accessed: October 15, 2019

Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., & Upham, P. (2015). International trends in public perceptions of climate change over the past quarter century. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(1), 35-61. doi:10.1002/wcc.321

Carolan, M., & Stuart, D. (2016). Get real: climate change and all that 'it'entails. *Sociologia Ruralis*, *56*(1), 74-95. doi:10.1111/soru.12067

Cheveau, M., Imbeau, L., Drapeau, P., & Bélanger, L. (2008). Current status and future directions of traditional ecological knowledge in forest management: a review. *The Forestry Chronicle, 84*(2), 231-243. doi:10.5558/tfc84231-2

Cubbage, F., Harou, P., & Sills, E. (2007). Policy instruments to enhance multi-functional forest management. *Forest Policy and Economics*, *9*(7), 833-851. doi:10.1016/j.forpol.2006.03.010

Davidson, D. J., Williamson, T., & Parkins, J. R. (2003). Understanding climate change risk and vulnerability in northern forest-based communities. *Canadian Journal of Forest Research*, *33*(11), 2252-2261. doi:10.1139/X03-138

Demski, C., Capstick, S., Pidgeon, N., Sposato, R. G., & Spence, A. (2017). Experience of extreme weather affects climate change mitigation and adaptation responses. *Climatic Change*, *140*(2), 149-164. doi:10.1007/s10584-016-1837-4

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., ... & Bartuska, A. (2015). The IPBES Conceptual Framework—connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1-16. doi:10.1016/j.cosust.2014.11.002

Dietz, T., Fitzgerald, A., & Shwom, R. (2005). Environmental values. *Annual Review of Environment and Resources*, *30*, 335-372. doi:10.1146/annurev.energy.30.050504.144444

Driscoll, D. (2019). Assessing Sociodemographic Predictors of Climate Change Concern, 1994–2016. *Social Science Quarterly (Wiley-Blackwell)*, *100*(5), 1699–1708. doi:10.1111/ssqu.12683

Dunlap, R. E. (2013). Climate change skepticism and denial: An introduction. *American Behavioral Scientist*, *57*(6), 691-698. doi:10.1177/0002764213477097

Dunlap, R. E., & McCright, A. M. (2008). A widening gap: Republican and Democratic views on climate change. *Environment: Science and Policy for Sustainable Development*, *50*(5), 26-35. doi:10.3200/ENVT.50.5.26-35

Failing, L., & Gregory, R. (2003). Ten common mistakes in designing biodiversity indicators for forest policy. *Journal of Environmental Management*, *68*(2), 121-132. doi:10.1016/S0301-4797(03)00014-8

Government of Alberta. (2019). Forest management agreements. Available from https://www.alberta.ca/forest-management-agreements.aspx. Accessed: August 23, 2019

Homer, P. M., & Kahle, L. R. (1988). A structural equation test of the value-attitude-behavior hierarchy. *Journal of Personality and Social Psychology*, *54*(4), 638-646. doi:10.1037/0022-3514.54.4.638

Hull, R. B., Richert, D., Seekamp, E., Robertson, D., & Buhyoff, G. J. (2003). Understandings of environmental quality: ambiguities and values held by environmental professionals. *Environmental Management, 31*(1), 1-13. doi:10.1007/s00267-002-2812-6

Hull, R.B., & Robertson, D.P. (2000). The language of nature matters: we need a more public ecology. In: Gobster, P., Hull, R.B. (Eds.), *Restoring Nature: Perspectives from the Social*

*Sciences and Humanities* (pp. 97–118). Available from: https://www.fs.usda.gov/treesearch/pubs/12560. Accessed July 5, 2019

Ives, C. D., & Kendal, D. (2014). The role of social values in the management of ecological systems. *Journal of Environmental Management*, *144*, 67-72. doi:10.1016/j.jenvman.2014.05.013

Jones, N., Shaw, S., Ross, H., Witt, K., & Pinner, B. (2016). The study of human values in understanding and managing social-ecological systems. *Ecology and Society*, *21*(1), 294-303. doi:10.5751/ES-07977-210115

Kauffman, J. B. (2004). Death rides the forest: perceptions of fire, land use, and ecological restoration of western forests. *Conservation Biology*, *18*(4), 878-882. doi:10.1111/j.1523-1739.2004.545_1.x

Keenan, R. J. (2015). Climate change impacts and adaptation in forest management: a review. *Annals of Forest Science*, *72*(2), 145-167. doi:10.1007/s13595-014-0446-5

Kolström, M., Lindner, M., Vilén, T., Maroschek, M., Seidl, R., Lexer, M. J., ... & Marchetti, M. (2011). Reviewing the science and implementation of climate change adaptation measures in European forestry. *Forests*, *2*(4), 961-982. doi:10.3390/f2040961

Luckert, M. K., & Williamson, T. (2005). Should sustained yield be part of sustainable forest management? *Canadian Journal of Forest Research*, *35*(2), 356-364. doi:10.1139/X04-172

Lynam, T., De Jong, W., Sheil, D., Kusumanto, T., & Evans, K. (2007). A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management. *Ecology and Society*, *12*(1), 1-15. doi:10.5751/ES-01987-120105

McCright, A. M., & Dunlap, R. E. (2011). Cool dudes: The denial of climate change among conservative white males in the United States. *Global Environmental Change, 21*(4), 1163-1172. doi:10.1016/j.gloenvcha.2011.06.003

McFarlane, B. L., & Boxall, P. C. (2000). Factors influencing forest values and attitudes of two stakeholder groups: The case of the Foothills Model Forest, Alberta, Canada. *Society & Natural Resources*, *13*(7), 649-661. doi:10.1080/08941920050121927

McFarlane, B. L., & Hunt, L. M. (2006). Environmental activism in the forest sector: Social psychological, social-cultural, and contextual effects. *Environment and Behavior*, *38*(2), 266-285. doi:10.1177/0013916505277999

McFarlane, B. L., Stumpf-Allen, R. C. G., & Watson, D. O. (2006). Public perceptions of natural disturbance in Canada's national parks: the case of the mountain pine beetle (Dendroctonus ponderosae Hopkins). *Biological Conservation*, *130*(3), 340-348. doi:10.1016/j.biocon.2005.12.029

McIntyre, N., Moore, J., & Yuan, M. (2008). A place-based, values-centered approach to managing recreation on Canadian crown lands. *Society and Natural Resources*, *21*(8), 657-670. doi:10.1080/08941920802022297

Moshofsky, M., Gilani, H. R., & Kozak, R. A. (2019). Adapting forest ecosystems to climate change by identifying the range of acceptable human interventions in western Canada. *Canadian Journal of Forest Research*, *49*(5), 553-564. doi:10.1139/cjfr-2018-0076

Moyer, J. M., Owen, R. J., & Duinker, P. N. (2008). Forest values: A framework for old-growth forest with implications for other forest conditions. *The Open Forest Science Journal*, *1*(1), 27-36. doi:10.2174/1874398600801010027

Myers, T. A., Maibach, E. W., Roser-Renouf, C., Akerlof, K., & Leiserowitz, A. A. (2013). The relationship between personal experience and belief in the reality of global warming. *Nature Climate Change*, *3*(4), 343-347. doi:10.1038/NCLIMATE1754

Nocentini, S., Buttoud, G., Ciancio, O., & Corona, P. (2017). Managing forests in a changing world – The need for a systemic approach. A Review. *Forest Systems, 26* (1), 1-15. doi:10.5424/fs/2017261-09443

O'Brien, E. A. (2003). Human values and their importance to the development of forestry policy in Britain: a literature review. *Forestry*, *76*(1), 3-17. doi:10.1093/forestry/76.1.3

O'Flaherty, R. M., Davidson-Hunt, I., & Manseau, M. (2008). Indigenous knowledge and values in planning for sustainable forestry: Pikangikum First Nation and the Whitefeather Forest Initiative. *Ecology and Society*, *13*(1), 1-11. doi:10.5751/ES-02284-130106

Oliver, M., Deal, R., Smith, N., Blahna, D., & Kline, J. (2016). What people value: an ecosystem services approach to managing public lands. *Science Findings 188, 1-5. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.* Available from: https://www.fs.usda.gov/treesearch/pubs/52223. Accessed: August 15, 2019

Owen, R. J., Duinker, P. N., & Beckley, T. M. (2009). Capturing old-growth values for use in forest decision-making. *Environmental Management*, *43*(2), 237-248. doi:10.1007/s00267-008-9133-3

Rahmstorf, S. (2004). The climate skeptics. In Munich Re (Ed.), *Weather Catastrophes & Climate Change* (pp. 76-83). Available from: http://www.pik-potsdam.de/~stefan/Publications/. Accessed: August 28, 2019

Satterfield, T., Gregory, R., Klain, S., Roberts, M., & Chan, K. M. (2013). Culture, intangibles and metrics in environmental management. *Journal of Environmental Management*, *117*, 103-114. doi:10.1016/j.jenvman.2012.11.033

Schmid-Petri, H., Adam, S., Schmucki, I., & Häussler, T. (2017). A changing climate of skepticism: The factors shaping climate change coverage in the US press. *Public Understanding of Science*, *26*(4), 498-513. doi:10.1177/0963662515612276

Semenza, J. C., Hall, D. E., Wilson, D. J., Bontempo, B. D., Sailor, D. J., & George, L. A. (2008). Public perception of climate change: voluntary mitigation and barriers to behavior change. *American Journal of Preventive Medicine*, *35*(5), 479-487. doi:10.1016/j.amepre.2008.08.020

Statistics Canada. (2017). Whitecourt [Population centre], Alberta and Hinton [Population centre], Alberta (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E. Accessed August 24, 2019

Steel, B. S., List, P., & Shindler, B. (1994). Conflicting values about federal forests: A comparison of national and Oregon publics. *Society & Natural Resources, 7*(2), 137-153. doi:10.1080/08941929409380852

Sudman, S., & Kalton, G. (1986). New developments in the sampling of special populations. *Annual Review of Sociology*, *12*(1), 401-429. doi:10.1146/annurev.so.12.080186.002153

Tindall, D. B. (2003). Social values and the contingent nature of public opinion and attitudes about forests. *The Forestry Chronicle*, *79*(3), 692-705. doi:10.5558/tfc79692-3

Wang, S. (2004). One hundred faces of sustainable forest management. *Forest Policy and Economics*, *6*(3-4), 205-213. doi:10.1016/j.forpol.2004.03.004

Williamson, T. B., Price, D. T., Beverly, J. L., Bothwell, P. M., Parkins, J. R., Patriquin, M. N., ... & Volney, W. J. A. (2007). *A framework for assessing vulnerability of forest-based communities to climate change*. https://cfs.nrcan.gc.ca/publications?id=27507

Yaffee, S. L. (1999). Three faces of ecosystem management. *Conservation Biology*, *13*(4), 713-725. doi:10.1046/j.1523-1739.1999.98127.x

Zanocco, C., Boudet, H., Nilson, R., Satein, H., Whitley, H., & Flora, J. (2018). Place, proximity, and perceived harm: extreme weather events and views about climate change. *Climatic Change*, *149*(3-4), 349-365. doi:10.1007/s10584-018-2251-x

# Chapter 3: Risk Perception of Genomic Selection in Tree Breeding

## Introduction

The emergence of new technologies provides opportunities for publics to assess the potential value of those technologies, and evaluate whether the perceived risks are worth taking. Public risk perceptions are important to consider given that attitudes do not change easily even when presented with new information (Hansen, Holm, Frewer, Robinson, & Sandøe, 2003) and perceptions about reality can potentially help determine public reactions or behaviors to new technologies (Slovic, Fischhoff, & Lichtenstein, 1982). Recent risk perception studies on nanotechnology have used upstream research which "…involves monitoring perceptions before […] any hint of controversy can be detected" (Satterfield, Kandlikar, Beaudrie, Conti, & Harthorn, 2009, p.752). Whether genomic selection studies in forestry can be considered upstream research is not clear as it has roots in agriculture, and may be viewed by publics as another biotechnology akin to genetic modification, but at the same time the vast majority of publics are likely to be unaware of genomic selection and its potential utilization in forestry. Identifying risks associated with emerging technologies, such as genomic selection prior to implementation can help in the anticipation of the potential future reception of publics, and to identify key areas of concern to be addressed before conflict emerges. Many efforts to include publics often come too late or even after implementation has occurred (Pidgeon & Rogers-Hayden, 2007), making no substantial difference in choices made about a particular technology. While unlikely to be avoided, risk perception studies before implementation can offer managers and policy makers with a better understanding of the nature of concerns that might contribute to public disapproval. The use of genomic selection in tree breeding is a clear example of a technology in which public risk perception may very well lead to strong opposition given the strong emotional ties people have towards forested environments and their attitudes towards biotechnologies.

In this study a few key questions will be asked: Firstly, what is the relative awareness of tree breeding efforts for those working in the forestry sector and for recreation stakeholders living in forest-based rural communities? Secondly, what are the risks that various stakeholders associate with genomic selection application in forestry? This chapter begins with a literature review looking at what risk entails. A few risk theories that are prominent in risk literature and pertinent to this study will be explored. Furthermore, references to work concerning public attitudes to biotechnology, such as genetically modified organisms (GMO's) in agriculture, will also be examined as the themes found in that field have repercussions for this work. A methods section will follow detailing how this study was conducted. After that an extensive findings section will identify some of the key risk characteristics that were found to be associated with genomic selection. A brief discussion and conclusion will end this chapter and will highlight the limitations and main takeaways of the study.

## Literature Review

Before any risk theories can be examined, it is useful to unpack what the concept of risk entails as there are many different meanings associated with risk. The concept of risk has been used to examine different technologies and in different capacities. As such, "talking about risks faces the immediate danger that everybody talks about something different" (Renn, 1998, p.50). Historically, risks are associated with a particular hazard and the probability of different outcomes, with varying degrees of harm, of employing that hazard (Vasvári, 2015). Renn (1998) explains that risks contain qualities that are uncertain and impact what people find significant. However, what is seen as likely and severe for one individual may not necessarily be the same for another. When considering new technologies, such as genomic selection, risk plays an important role as acceptance is often contingent on perceptions of risks and benefits (Siegrist, Cvetkovich, & Roth, 2000). This evaluation of risks and benefits is not stationary, but rather a continuous reassessment of what is acceptable. There is recognition that benefits and risks are not separate, but can influence each other (Siegrist, 2000; De Groot, Steg, & Poortinga, 2013). Alhakami and Slovic (1994) find that benefits and risks share an inverse relationship and thus, hazards which are seen as quite risky tend to be seen as less beneficial. Others, particularly Cultural Theory scholars, have argued (Douglas & Wildavsky, 1983) that the expressed risks or benefits of a technology are not solely features of the technology itself, nor of individual psychological predispositions, but instead perceptions are based on an individual's worldviews. Most likely both cultural and psychological determinants influence risk perception (Leiserowitz, 2006), but how significant each of these are may change depending on the hazard examined.

When considering the many studies of risk: risk perception, risk analysis, risk assessment, risk management, and risk communication; risk can be understood as a pervasive concept within society and the management or mitigation of risks is held in much importance and debate. While scientific or rather statistical probability has been at the heart of conventional risk analysis, the study of risk perception has evolved beyond the technical to include multiple psychological and social dimensions (Vasvári, 2015). The study of risk is therefore as much a qualitative enterprise as it is a quantitative one. Technical experts have been commonly used to prescribe 'good' or 'sound' science to assess and overcome the risks related to new technologies (Finucane & Holup, 2005). However, experts' own notions of risk are not devoid of their own values and beliefs. Differences between experts have been observed to be partly attributed to disciplinarity, and despite being singularly grouped as experts, differences within this collective can be pronounced (Blok, Jensen, & Kaltoft, 2008). Therefore, since risk is subjective (Krimsky & Golding, 1992) what is risky for the lay individual is just as relevant for a technical expert. Herrick (2005) mentions that, "[s]ince the notion of risk breaks the scientific monopoly on truth, it leaves the field wide open to competing actors and their renditions of 'scientific' truth" (p.287). In the case of genomic selection, as much as scientific experts may rely upon science, stakeholders may experience their own truths through their social reasoning. That is not to say the risks seen by experts are insignificant, but to ignore public perceptions creates an opening for conflict. "When the differences between social and scientific notions of risk become acute, then the outcome is a 'social amplification of risk' by the public" (Herrick, 2005, p.287; see Kasperson *et al*., 1988 for an overview of social amplification of risk). In other words, when policymakers only address risks that are deemed important by experts, but fail to address the risks raised by publics, neither side understands the worries of the other. Beck (1992) acknowledges this as "fissures and gaps" (p.30).

The psychometric paradigm is one risk approach that has been a cornerstone for many risk perception studies. This paradigm examines risk characteristics of a particular hazard. Slovic (1987) highlights the multidimensionality of risk perception through two main dimensions: 'dread' and 'unknown' risk. This has traditionally been used in quantitative surveys in which scales are built (Dohle, Keller, & Siegrist, 2010), but has been used to inform qualitative or mixed methods studies as well (for instance, Shaw, 2002; Gaskell *et al*., 2004). According to

Finucane and Holup (2005) a dread risk “is seen as dreaded, uncontrollable, fatal, not equitable, high risk to future generations, not easily reduced, involuntary, and potentially catastrophic” (p.1604). On the other hand, unknown risk “reflects the extent to which a hazard is unknown, unobservable, unfamiliar, and has delayed consequences” (Finucane & Holup, 2005, p.1604). Along with these characteristics Slovic (1996) notes that unknown risks include whether a technology has been recently developed or is viewed as being unknown to science. Slovic’s (1987) early work looked at a variety of technologies, including DNA technologies, which were viewed as having both dimensions of risk. Thus, the reception towards a technology is not necessarily due to possible outcomes alone but can be partially driven by these qualitative risk characteristics (Gupta, Fischer, & Frewer, 2012). Along with these cognitive factors many other elements, such as social or political factors, have been incorporated into risk perception models (see Renn, 2008).

While the psychometric paradigm informs some of the work detailed in this thesis it is not without its criticisms. Specifically, Hansen *et al*. (2003) critique psychometric approaches for precluding broader social processes and meanings. It has been found deficient in explaining how a technology in one culture or society may be perceived more negatively than in another (Rippl, 2002). Touili *et al*. (2014) also criticize the paradigm for being “of little use when envisioning options for risk mitigation. Acknowledging the need for action, does not necessarily define the attitudes toward modes of action” (p.2). An additional criticism is that the paradigm has historically grouped people into the expert and lay classifications but has failed to further differentiate these groups (Armaş & Avram, 2008). While this study partially draws on the psychometric approach, I recognize that other risk approaches are valuable and provide further understandings of why particular risks are perceived (Hansen *et al*., 2003). More recently it has been found that factors other than ‘dread’ and ‘unknown’ characteristics can be significant in risk perception. For instance, Siegrist *et al*. (2000) found that trust is another element in both perception of risks and benefits. However, the degree of significance that trust can play in risk perception is not completely straightforward (Sjöberg, 2004) indicating that trust may only be a small factor in some cases. Additionally, Sjöberg (2000) finds that perceived “unnatural and immoral” (p.4) characteristics of a technology do a great deal to explain perception. The way in which individuals deem interactions with environments appropriate or not are, therefore, another risk perception dimension and one of importance due to the way technologies often initiate discussions around human interactions with nature. As found with biotechnologies, questions are often raised about "the degree to which scientists' visions of increased technological control over both Nature and human society could ever be ethically acceptable" (Pidgeon *et al*., 2012, p.4193). Thus, attention beyond uncertain and dread characteristics will be identified in the latter half of this chapter.

There has been extensive research detailing public perceptions of new biotechnologies. A quick overview of some risk perception studies in agriculture is necessary as the number of risk perception studies concerning tree breeding are rare and no studies concerning public perceptions of genomic selection application in forestry were found. Analyzing similarly emergent, uncertain technologies is therefore quite useful and not without merit. For instance, Flynn, Bellaby, and Ricci (2006) examined previous perception studies of nanotechnology, GMO's, and carbon capture and storage technologies to help inform public perceptions of risk in their own interests of hydrogen energy adoption. Similarly, looking at public perceptions of agriculture biotechnologies proved useful for this study. Indeed, numerous biotechnology risk perception studies have already been referenced (for example, Siegrist *et al*., 2000; Finucane & Holup, 2005). Interviews, as well as surveys of the European public, conducted by Gaskell *et al*. (2004) reveal that while perceptions are important for some, individuals that recognize only a few benefits of genetically modified crops better explain resistance towards biotechnology for a greater proportion of the European public. Likewise, a study related to public understandings of genetically modified food discovered several themes; primarily among these were "the uncertainty of scientific knowledge of GM food, genetic modification as inappropriate scientific intervention in 'nature'" (p.286) and how publics are nonhomogeneous when it comes to understandings of biotechnology (Shaw, 2002). Risk perception literature concerning biotechnology highlight interactions between natural and social systems as well as scientific institutions.

## Methods

Semi-structured qualitative interviews were conducted with participants in Edmonton, Hinton, and Whitecourt. Participants in Edmonton were contacted as their work within the government has repercussions for forestry in both of these rural communities as well as province wide. Hinton and Whitecourt were selected as case study communities on the basis of being natural resource dependent communities, the recreation opportunities available there, and their proximity to both national and provincial parks. Individuals were contacted based on whether they work in the forestry sector (both government and industry) or involved in a recreation group. These individuals are likely to be most engaged about forest management decisions such as implementation of a new technology. A focus was on trying to contact those who interact frequently within the forest (either professionally or recreationally) and who do not work with genomic selection in their occupation. Therefore, geneticists and individuals who work closely within tree breeding programs were avoided. Stakeholders were selected via snowball sampling in which potential interviewees were first contacted through email. The use of snowball sampling is advantageous that the connections between people allow researchers to access groups that are small or that are difficult to contact (Sudman & Kalton, 1986). An initial list of participants was gathered from the Foothills Research Institute. In addition, a few Government of Alberta employees with offices in Edmonton within the Agriculture and Forestry Ministry, and more specifically within the Forestry Division and the Forest Management Branch, but typically working in different sections were contacted through email which was available online. These participants greatly expanded the initial list of potential contacts in the Hinton and Whitecourt area. Twenty dollars was given as an incentive to participate. Participants were contacted until thematic saturation was reached. Interviews were audio recorded, except in one instance where notes were just taken. Additionally, interviews were conducted primarily in person except in two cases in which interviews were held over the phone. Each interview was transcribed and during transcription notes were taken to help establish key themes. After transcription, transcripts were imported into NVivo 12 and codes were created which formed the themes discussed in the results section. Each interview was assigned a unique number identifier. The methods described here was outlined in a research proposal and was approved by the University of Alberta Research Ethics Board (PRO00083831).

During the interview, questions were asked to understand the potential risks that are associated with the use of genomic selection in forestry. Questions pertaining to the knowledge of tree breeding and genomic selection were also asked. A subject's awareness of tree breeding and genomic selection involved a self-assessment as well as a critical piece, i.e. stakeholders were asked how knowledgeable they think they are and to describe what they think each term entails. For those who had no prior knowledge of tree breeding, a brief discussion pertaining to its general process and goals was provided. Moreover, for each interview, a script was read providing an overview of genomic selection which highlighted the potential benefits of such use. While members of rural communities can be expected to have a greater knowledge of forestry activities, their knowledge of specialized forestry activities such as tree breeding and even more niche areas such as genomic assisted tree breeding were not expected to be high, thus it was deemed necessary to provide an overview of the technology to help facilitate discussion.

The final sample included 23 individuals: 16 currently working in the forestry sector, five who are involved in recreation groups, but have previous forestry experience (retired or switched careers), and finally, two individuals who had no forestry work experience, but were involved in recreation clubs. Those working in the forestry sector included, but were not limited to: ecologists, forest health officers, layout contractors, and foresters (assistant, planning, operations, silviculture). As a result of the snowball sample, some individuals had management roles, while others worked primarily in the field. The companies of Blue Ridge in Whitecourt and West Fraser in Hinton were the primary sources of respondents with upper management often providing contacts to those who had less of a managerial role. From the areas of interest four participants came from Edmonton, 11 from Whitecourt, and eight from Hinton. The sample contained primarily middle-aged men with the majority of participants (16) falling between the ages of 40 and 60, three people older than 60, and four individuals younger than 40. Out of the 23 individuals seven were women and 16 were men. Recreation users were members of the following: Whitecourt Trailblazers, Whitecourt Fish and Game Association, Hinton Mountain Bike Association, Hinton Nordic Ski Club, and the Hinton ATV Society. Contacting other employees from other companies and recreationists from other clubs was attempted, but unsuccessful as no interested participants were heard from.

## Findings

*Tree Breeding & Genomic Selection Awareness*

Each interviewee was categorized based on their knowledge and perceptions of tree breeding and genomic selection. These categories were the following: known and specified, known and unspecified, and unknown. These categories were drawn from Simons *et al*. (2009) who compared different studies that examined nanotechnology awareness. Participants were found to have a strong awareness of tree breeding, but were much less aware of genomic selection. Respondents who were classified as "known and specified" acknowledged that they were familiar with the term and articulated their understanding of what it means. Individuals who were classified as known and unspecified had heard the term, but were unable to give an accurate description. Finally, those who were classified as unknown simply had not heard the term before. For the numerical distributions for each of these categories see Table 1.

Those classified as 'known and specified' were not, however, experts. Participants frequently pointed this out describing themselves as, for example, "probably more knowledgeable than the average person. I'm not an expert by any stretch…" (Forester, Whitecourt, 3.1). In fact, some who fell under this classification failed to mention terms such as "breeding value(s)," "genetic gains," or "progeny tests"; all of which would be common vocabulary for any tree breeder or geneticist. Orchards were mentioned more frequently, but not usually explained in depth. There was a group of participants, with no apparent shared characteristics within the group, who most often associated tree breeding with only the collection of cones. While this is certainly not incorrect, it is only one small part of tree breeding. So, while two individuals may be categorized as 'known and specified' for tree breeding or genomic selection what that actually means for each individual goes beyond simple classifications. Therefore, while interviews were grouped in these categories for easy comparisons, their understandings of tree breeding and genomic selection are fairly nuanced.

One reason for this awareness of one stage of the tree breeding process (cone collection), but not others could be due to visibility. For instance, one recreationist from Whitecourt (3.10) explains: "I have seen some of the harvesting of the cones in my prior job when we had probably just say exceptional trees along our lease roads for example and I have seen them harvesting the cones from a helicopter from these particular trees…" Cone collection is something that is visible when working or otherwise doing recreation activities in the forest, but orchards and more specifically, what happens within them are layered in obscurity. For example, a forester from Hinton (1.4) who was quite familiar with genomic selection trials had the following to say: “But, like, um, as an example all of our test sites they are all signed and they say it’s a field research site, but they don’t say it’s a genetic test site.”

Table 1: Number of participants classified by their degree of awareness of the terms tree breeding and genomic selection. ‘Known and specified’ indicates a participant was aware and attempted to explain what they believe the term means. ‘Known and unspecified’ indicates that the participant has heard the term, but is unable to describe what it means. ‘Unknown’ being both unaware and unable to describe the term.

| **Term** | **Known & Specified** | **Known & Unspecified** | **Unknown** |
|---|---|---|---|
| **Tree Breeding** | 20 | 2 | 1 |
| **Genomic Selection** | 6 | 7 | 10 |

*Tree Breeding Perceptions*

While the overall goal of this study was not to explore tree breeding perceptions, it is important to note that since genomic selection is a tool to aid tree breeding efforts, it is, therefore, important to not examine the one without the other due to the potential relations between the two terms. For example, examining whether a positive perception of tree breeding may also indicate a positive perception of genomic selection would be informative. Overall, tree breeding was valued quite highly and was seen as a tool to make forests more efficient. For instance, one forest industry worker (3.9) commented that “[a]s a company of West Fraser we believe it’s important and it’s important for basically one reason and probably the only, is to get the biggest, fastest growing, best trees on the site.” Other benefits were also realized as mentioned by a government employee (2.2) in Edmonton: “You could also be breeding trees in order to achieve some sort of resistance, you know, to western gall rust or, um, making trees more resistant to drought.” The overall sample was quite supportive of tree breeding efforts regardless of relative awareness.

However, there were a few individuals that expressed concerns about tree breeding. Both in terms of marginal gains and how it can negatively impact future forest conditions. In one case, a government employee of Hinton (1.5) had the following to say: “So, there are- there’s ramifications I think, long term ramifications, on the backend if we were to employ it en masse and do it everywhere. And I think there’s, there’s, something to be said for the variation of demographics in a healthy forest” and when genomic selection was introduced to them they replied “[s]o, I think my answer is still kind of the same.” Interestingly, the perceived risks that were associated with tree breeding carried over when discussing genomic selection. So, while genomic selection certainly has its own risks, as will be discussed below, those who found aspects of tree breeding to be risky found similar risks with genomic selection despite the increased amount of information that genomic selection offers to breeders.

*Genomic Selection: Lack of Benefits*

The perceived benefits of genomic selection were hard to measure as most individuals had not previously heard of genomic selection in forestry. So, when suddenly confronted with the term genomic selection, participants relied upon and frequently cited the benefits that were given. Therefore, the realized benefits of this study were not frequently captured as participants had not contemplated or had a chance to observe what benefits genomic selection entails by the time of the interview. Despite this, there were those who already perceived that genomic selection may not provide any benefit to the public and thus, genomic selection, from the perspective of these individuals, may only benefit industry purposes. One participant states:

> Well, you need trees to die. You need trees with tilted tops. You need trees with forks. You need trees with traits that are not desirable for a lumber mill. A pulp mill could probably care less. But, no one likes to see, even if it has a fork or two in it or a broken top, no one wants to see a forty centimeter white spruce straight as an arrow head straight to a chipper. Right? So, it’s always going to go, and more so in the future, it’s always going to go to a sawmill. So, that’s great for the sawmill, but part of that ecosystem requires what the lumber industry calls junk trees as part of their habitat. So, you always- If you want to maintain the ecosystem you have to- Again, it comes back to what does the public want? They want that species on the landscape. They want that species of dickie bird or ungulate or, or, you know, predator of some kind to do well and if they say yes

> and what is it going to take? And if you are going to be like a super manager and you have to manage to have that or you've errored. ~Contractor, Whitecourt (3.7).

Another participant expressed similar views that public values may not be best served through genomic selection use:

> Like if there was an area where you do intensive forest management and you wanted to grow big and healthy trees and that part of the forest is what it is used for is for basically creating timber then sure that might be an area, but there might be an area where there's recreational values or biodiversity values or there are other values out there that you might want to avoid using some genomic selection and just use like wild or natural selection. […] This stuff may show no value to the public, but it might show a lot of value to, um, forest industry. ~Forester, Whitecourt (3.9).

Benefits related to genomic selection were seen as possibly unjust or unfair because industry was perceived to benefit the most. There was a recognition that having trees with desirable traits that are only desirable for the forest industry is not socially acceptable and does not fit within their ideas of what constitutes socially sustainable forests. Both of the above quotes represent individuals who felt that genomic selection might create value for industry, but other values might be neglected. Specifically, the last quote refers to benefits that can only be obtained through natural processes which excluded genomic selection use. Hence, genomic selection was perceived by some to be acceptable under certain conditions (intensive forestry), but unsuitable for other areas and especially areas valued by the public. Finally, the same contractor from Whitecourt (3.7) had the following to say about using genomic selection to adapt to climate change:

> Just increasing yield is one thing. Um. If you are going to make it so you can go across all seed zones and you can plant it north to south and you think you are going to beat global warming and its affect, because global warming seems to be the planet earth's trend at the moment. Right? You think you are going to be able to beat that, uh, with some genetic tinkering and you are going to bank on that and you are going to bank Canada's resources on that I think that would be very presumptuous, but if you are going to use it to increase yield for the sake of planet earth, like we've done to feed people

> through agriculture, you know- So, there's your benefit, but I wouldn't want to see us getting kind of cocky and arrogant.

This individual clearly felt that genomic selection might not provide benefits in terms of drought tolerance or pest resistance. Thinking that it can address climate change and consequent overuse of the technology due to overconfidence was seen as reckless. So, while they identified that genomic selection had some benefit through increased yield, they were skeptical of any climate adaptation benefits.

*Genomic Selection: Perceived Risks*

*Model Accuracy*

A common theme among participants was skepticism about the accuracy of the models used, and the extent to which they were scientifically sound. For example, one government worker (3.2) stated "Like models- There are always a bit of room for error in models." The quality of the data used for modelling was closely associated with the risk associated with genomic selection. The perceived risks of model inaccuracy were conveyed by individuals currently working in the government and the forest industry; no participants from recreation groups or who had previous forestry experience conveyed this concern. That is to say, their experiences with other models are reflected in their reception towards genomic modelling. One participant explained how their confidence in the models they currently use for forest management and for genomic selection will depend on the degree to which the model is validated:

> So, yea, if there was a process that shortened that up that had some sort of validity then- That's always the catch with models is that, you know, are they validated? […]. Yea, models are just a tool and it's sort of you know like the old saying it's as good as the data you put in it. Right? And, uh, also sometimes with modelling like it's hard- it can be a black box where you're not exactly sure what's doing what. Um. So, I mean, I work with models all the time in FMP's, right? That's what we do. We have marten models, barn owl models, obviously forest growth models, and grizzly bear models, and like song bird models, and the list goes on and on and on with the models that we deal with, but- And they all have, uh, different degrees of validation. Like some of the models we use aren't

validated at all and, uh, some are and some are somewhat validated. So. Yea, I guess, I mean, if it's, if it's, a model that is validated and, uh, you know, is shown to work there's really no down side to that. It speeds up a process. ~Forester, Hinton (1.2).

Many participants recognized the potential for human error and the need to have models that are statistically sufficient. However, not all experiences with modelling were negative. A forester from Whitecourt (3.3) indicated that "[g]enomic testing to understand how, um, how particular that gene or that tree will respond and we can build predictive modeling after that that would be of use because I'm all about predictive modeling. We model out to two hundred years. I understand modeling. I'm good with modeling. I think modeling is important…" In this case the familiarity with modelling served to support genomic modelling efforts. However, model accuracy was not the only concern raised throughout these interviews. One participant (1.4) found that it "[a]ll depends on how you use it and how robust your models are. Um. If you train a shitty model you are going to get shitty results and there's no avoiding that, but if you program an extremely robust model you are probably going to get very, uh, reliable results." Model accuracy for this individual was important, but the context in which genomic selection will be used proved to be a source of concern.

*Decreasing Complexity in Complex Environments*

By far the most compelling and dominant theme expressed by participants in this study was the concern that the adoption of genomic selection could lead to forests that are less complex. Maintaining complex or diverse environments is a criteria that publics often deem important as it often constitutes what is seen as a healthy forest (Kelly & Bliss, 2009). Simplified environments have been shown to create disastrous forest conditions with the most recent example being western Canada where a range of human activities to support the (over)reliance of pine forests (Richardson *et al*., 2007) has led to severe mountain pine beetle outbreaks. Throughout the interviews, there was a recognition of past mistakes and trepidation about making similar ones in the future. Two closely interrelated themes were found to center around the perception of decreasing complexity via genomic selection. These themes were not mutually exclusive as they exhibit strong relations with one another. For instance, by using genomic selection extensively it could be perceived that genetic diversity would decrease and the resulting decrease in diversity could lead to greater chances of unknown environmental consequences.

These strong relationships can be seen below with multiple themes sometimes occurring in a single quote. The importance of these themes reflects how participants judge how genomic selection is being used and the extent to which it will be implemented on the landscape.

1. *Genetic Diversity*

Individuals expressed concern that genetic diversity had the potential to be lowered by the use of genomic selection. For instance, a recreationist from Whitecourt (3.6) expressed that "[y]ou don't want to have it so there's only this, this, is a lodgepole pine and there's no difference between that lodgepole pine and that lodgepole pine. When you pull a sample of them, their genetic makeup is identical from here all the way up to the Northwest Territories kind of thing." The potential for genomic selection to create few genetic differences amongst trees was clearly expressed here. How and even if genetic diversity was being maintained was a recurring theme even amongst foresters. For example, a forester from Whitecourt (3.8) articulated that "I think we should be cautious to make sure there's no other, uh, collateral effects on how we manage our forests and the genetic diversity that we would want to see within our natural systems…" Genetic diversity was found to be related to natural forest conditions and maintaining those conditions were consequently quite important for this individual. One participant even went to the extent that genomic selection could create monocultures:

> I: It is poor in that it [genomic selection] kind of grows monocultures which as we've kind of had our whole conversation is not the best thing quite often in a natural system…
>
> A: Um. Ok. You said it could create monocultures. I'm wondering if you could talk a little bit more about that.
>
> I: Yea, so, I always bring it back to farming because I grew up in a farming community. So, quite often you'll plant a field that is just one strain of wheat. That is it. So, that's a monoculture. There's only one thing there. The system is not complex; it is very simple. You know exactly what you have. That's what I would call a monoculture. And we could do it in forestry kind of as well because say we plant a whole block, pure pine, we cut down all the competition, it is just pine. That's a monoculture, but it is still genetically variant while that crop of wheat is genetically similar meaning that they will have the

same response to whatever disturbs them. Generally. While the crop of trees they will all kind of react differently to different factors acting on them.

A: Yea, that makes sense. So, you were concerned about the genetic differences?

I: Yea.

~Forester, Hinton (1.1).

The broad scale application of genomic selection was an important area of concern. For instance, a recreationist from Whitecourt (3.5) had this to say about the use of genomic selection:

> More of my concern would be you just said like we did a while back. Like that's no good over there anymore we need to do this. So, you take a tree that is a superior tree and now you sell that as a solve all. […]. That's my same thought is that it doesn't apply everywhere. It doesn't make sense everywhere.

The worry that genomic selection could be overused or applied in such a way to promote only desirable stock was emphasized by people other than just recreationists. A forester (3.9) asserted that: "I don't think we should be going out there and picking the best of one tree family or whatever and spreading that across the whole FMA." In this way, the extent to which genomic selection is being used and how more than just desirable trees should be planted was a perceived risk. For many, genomic selection was a tool that could lead to similarities amongst trees and this was cause for apprehension. This individual highlights their uneasiness:

> You don't want to get too carried away with it I think cause it- […]. It's kind of like trying to bring back the whooping crane. When you only have two or three left it's kind of hard to make a little bit of genetic differences in their offspring when you only have so much to start with. You don't want to make it like that so there's no div- It's not diversity, but it's, um, you don't have like one strain over everywhere. (3.6).

In this way, participants were concerned about the use of genomic selection extensively across the landscape as well as using only one genetically superior tree or family. An acceptable balance between using genetically improved stock and naturally regenerated stands was something participants were trying to negotiate. For some individuals this was achieved by having specific areas or zones designated only for genetically improved stock.

2. *Environmental Harm & Scientific Limitations*

Many participants expressed the concern that the use of genomic selection could cause unknown environmental harm that was not foreseen by science or scientists. One individual (3.8) held this attitude stating "I think right now the trepidation might be about the fact of the lack of knowledge around what this may or may not mean for our natural environment." Individuals who voiced this opinion questioned the ability of scientists to understand the ramifications of actions made today that might not be seen for many years. For instance,

> Like one is you might do all this and then twenty years down the road stuff we didn't factor in pops up. Like maybe, maybe, you make one tree more resistant to the pine beetle, but it is less resistant to a different type of bug and that explodes and we didn't know that. So, there's these unknowns and these risks that happen that you don't know till later on and because we are talking trees, like you said, it takes twenty or thirty years to know what happens. ~Recreationist, Whitecourt (3.11).

For some the unknown consequences of genomic selection was related to the complexity of genomic research:

> Like the forestry that we do now we kind of in a way have been doing it for hundreds of years. You get a seed, you plant a tree, you watch it grow, it needs water, sun, a good site. While genomics is something so different that we don't really have the data to see how it is going to work. So, we might think we have something genetically superior and it is inferior. (1.1).

> I wonder a little bit it could be a bit of slippery slope. I constantly feel young and humble and daunted with our knowledge level compared to what's actually going on and maybe when you start tinkering with one thing maybe you miss another marker that's really important for a disease or a climatic event further down. So, we got to be careful not to put all our eggs in one basket. At the same time, we do need to continue down that path and continue to explore it. (3.1).

For others perceived past mistakes made by the forestry or agricultural sector seemed to exacerbate the need for caution and increased cognizance of how human actions can unknowingly cause great harm to forests:

> I: So, again, lots of those things when you first mention it the first thing that comes to your mind is well okay there's reasons- The reasons- You count- I guess I always think that you can't outthink mother nature. You can try to make improvements, but if you said I'm going to grow larch. Larch really is good commercial, good yield, and so on. And you find out that larch is poisonous to squirrels or whatever.
>
> A: Right.
>
> I: Whatever those issues become. That it is susceptible to fire. It's susceptible to disease at sixty years or something like that. So, same as the pine. We had- They were converting spruce stands into pine stands when I was early in my career. That was what you needed to do because pine grows faster. It's way better. Well, jeez, the beetle came along and ate all the pine. Now where are we? So, those decisions like that you start thinking about those things. Like are you- What about this? Well, I mean, the first word is think and that's what you need to do because again, in that example, we had, we had, converted a lot of aspen stands to pine we converted a lot of spruce stands to pine because we thought it was better success, better able to meet the targets that the government had at the time around free to grow and all that other jazz.
>
> A: Right.
>
> I: Little did we know that the beetle was going to eat it all or become a major influence on the landscape that impacts it. Right? (3.5).
>
> I mean, yes, they are developing a tree that will be more robust and more problems or pestilence or whatever comes along, but they've done the same thing with grain. So, my relatives farm in Saskatchewan. What my Dad- Well, what my Uncle used to farm when they were young what they can get off an acre they used to get off a section because now they made the grain with a shorter stock, bigger head so that it is not prone to lodging because it has a shorter stock. Bigger head means higher yield. But, in doing so they

> really screwed up bad. They have changed- I'm gluten intolerant. They have changed the gluten molecule. […]. So, it's a bonus and it's a minus. You get to feed more people, but you have more health problems in people. So, with trees I don't know what the health problems would be or the issues would be, but guaranteed there will be something. Man gets in there and messes with stuff and by the time they realize, it's not a good thing; it's usually too late. ~Recreationist, Hinton (1.3).

The latter example is especially intriguing as the participant associates genomic selection as being similar to GMO's and recognizes there might not be any health risks directly associated with forestry use, but strongly states that nonetheless something problematic would occur. Individuals who perceived the prior theme, of a potential reduction in genetic diversity, tended to stress the potential for unknown environmental harm:

> So, if we were to only have these genetically improved trees out there, it's no different than only having one species of tree and how does that impact the resiliency of the forest? And it might be, it might be, a really good gene for the 3 or 4 things that we are narrowly looking at, but we might find out in 80 years it is a terrible gene for a disease that wasn't even on our radar. So, that concerns me a little bit in terms of the future health of forests and if we were to employ it across the board. (1.5).

This participant expressed that resilient forests were not achievable through genomic selection use. They believed that by using genomic selection broadly and only looking at segments of DNA that corresponded to desirable traits could lead to undesirable future conditions.

*Genomic Selection As A New Technology?*

Agriculture was referenced in many interviews both in relation to tree breeding and genomic selection. In this study, genomic selection was framed as a relatively new technology for application in forestry. However, there were some instances where participants disagreed with how new and unknown genomic selection was and that influenced how risky they perceived it to be. Whether or not genomic selection is considered a new technology can be understood as a social construct. One participant expressed that genomic selection has been ongoing for quite some time, was quite receptive of genomic selection use because they mentioned that it has been used in agriculture successfully and determined the terms genomic selection, selective breeding, and genetic modification as being fairly synonymous.

> I: It's like, like I said, they do it with wheat. Well, ok, this one protects against that thing and this thing. And canola, you hear about it all the time. It makes root rot and this and that and the other thing and they mature faster. […]. Well, they've been doing that for hundreds of years, but they used to just take the pollen from one plant with good qualities and put it in another one. Genetically modifying it right there, but they didn't call it that. Just cross pollination. [Laughs]. You know?
>
> A: Right.
>
> I: Same thing. It is. So, why- Natures been doing it for millions of years why can't we? We're just making it go faster. (3.6).

As such, the use of biotechnology in agriculture was used as a reference point and the consequent idea of using similar technology in tree breeding was not as unfamiliar. While not prominently found in the interviews conducted, whether or not genomic selection is viewed as a recent technology has ramifications on the relative risk that is perceived. The example here demonstrates that individuals adopting a perspective that humans are just helping nature adapt and realizing that we have been doing so for a long time are likely to have a positive reception to genomic selection.

*Ethical Considerations, Human Involvement in 'Natural' Environments*

As seen in the previous sections, ethical concerns were present, especially in relation to genetically modifying organisms, but this was not a prominent theme in the study. Ethics was not limited to genetic modification, however. Questions surrounding the level of human involvement within the environment was also a concern. For instance, one participant (1.1) stated that "[w]hen you start messing with the genetics of things, um, especially the genomic selection and say making a genetically modified things you are kind of playing God in a way…" Nonetheless, for those who associated genomic selection with genetically modifying organisms, they expressed ethical concerns and consequently rejection of its use. While genetically modified organisms can certainly create ethical issues, the use of genomic selection is something that may preside within an ethical gray zone. It is a level of human intervention that is greater than conventional tree breeding as there is more involvement with selecting traits, but it does not go as far as actual genetic manipulation. Not all participants however felt a clear boundary between the terms genomic selection and genetic modification and hence, the ethics of sound genomic selection was questioned. For instance:

> I: …Because the thing is if we plant genetically modified trees that like through a laboratory process we will be eliminating ourselves from markets. Potentially.
>
> A: To be fair genomic selection is not genetically modified.
>
> I: Ok. Can you tell me- How do I separate that in my head then? (3.3).

Other participants had clearer distinctions. One individual (3.7) expressed: "You're not exactly at the point of creating a designer tree, you know, in a petri dish. Um. Maybe we could, but I don't know if we, if we, need that." Another participant made a direct distinction that manipulation wasn't occurring and genomic selection was just speeding up a natural process. They began with an analogy about how genomic selection was similar to seedless grapes. They talked about how seedless grapes was a mutation that appeared in the wild, but humans have since propagated for consumption purposes. This participant went on to say that:

> Trees are going to try to protect themselves from that thing whatever it is. If we can help them do it a little faster, help them protect themselves from mountain pine beetle, is a good example, why wouldn't we? […]. There are, there are, hundreds, probably hundreds, of varieties of canola and wheat and stuff like that. So, like I say, as long as they don't make one type of tree, there's nothing wrong with that. Nature has been doing it for millions of years; we're just kind of pushing it along. (3.6).

While many participants did indicate that they had ethical concerns about genomic selection, many speculated that members of the public would also express this view. As one individual (1.4) put it, "I guess one potential barrier to tree breeding in general and genomic selection is definitely how the public views it. They hear genetics they think GMO's, but of course GMO's is not allowed in trees." Opinions such as these were found to commonly come from a perspective that presumes a lack of knowledge causes opposition and by promoting education, disputes will dissolve. For instance, a different forestry worker (1.8) in Hinton commented that when it comes to the public and genomic selection "[t]here's a lot of concern around genetically modified organisms. Uh. I just don't think that people are knowledgeable enough to actually understand that, but I do see people as not understanding or being against that kind of human intervention." Interestingly, some participants who expressed that the public would not know the 'real' risks associated with genomic selection also held the view that science did not have the answers either.

## Discussion

Those working within forestry and those living in forest dependent communities were found to be relatively aware of tree breeding, but had varying degrees of awareness of genomic selection, with many individuals being unaware. No differences were observed between those in different age or gender groups, but the small sample size does not allow for exploring these potential associations. In other larger studies (e.g. Siegrist, 2000), women were found to be less receptive to biotechnologies. Similarly, no distinct differences were found between recreation and forestry groups, with the exception of concerns about the efficacy of modelling. That is not to say that stakeholders were uniform in their understandings of what genomic selection is and where it fits within their own conceptualizations of forest ecosystems. As noted by Shaw (2002) publics and experts are often seen as two uniform collectives, but can be more nuanced.

The results highlight a variety of themes that correspond to Slovic's (1987) dimensions of risk, of which the following were most prominent: uncontrollability, equity, delayed consequences, and being unknown to science. Of particular importance, participants anticipated that genomic selection could lead to a reduction in ecological diversity. Interestingly, some proponents of genomic selection view it as a tool to help sustain genetic diversity, although this isn't always the case (see Grattapaglia, 2017). Specifically, Grattapaglia and Resende (2011) comment that "a common feature of tree breeding programs is the simultaneous advancement of populations for long-term genetic gains wherefrom new genetic diversity can be introduced in the fast-moving elite breeding populations where GS is applied" (p.253). Moreover, the use of GBLUP models "clearly demonstrates how genetic diversity can be managed while maintaining a focus on the attribute [trait] in question" (El-Kassaby, Klápště, & Guy, 2012, p.636). This presents a noticeable difference between stakeholder and some expert notions of risk as it relates to genomic selection.

Based on these perceived risks, respondents did not necessarily reject genomic selection entirely, but a cautionary approach to implementation was often advised. In particular, pilot projects and limited use of genomic selection was strongly encouraged. For some, these risks would be overcome in the near future. One such participant (3.9) expresses the need for "more information, more research. I think once there's sound research or whatever, then the barriers might lift." While not directly measuring acceptability in this study and despite the many risks participants expressed, only a few individuals completely rejected genomic selection. This is consistent with Zechendorf (1994) who states that "[e]ven when people assume that gene technology is associated with relatively high risks and rather unknown consequences, they do not reject biotechnology altogether" (cited in Siegrist, 2000, p.195). This study also supports the findings of Hajjar, McGuigan, Moshofsky, and Kozak (2014) who conducted a survey of acceptable climate approaches for forest management across Alberta and British Columbia and determined that using local seeds, tree breeding, and genetic engineering were most to least acceptable, respectively, for publics. In general, participants were more wary of reforestation methods that had increased human involvement within forested environments.

The hesitancy that participants felt towards genomic selection went beyond dread and unknown risks. This became particularly apparent when considering the large discrepancy between tree breeding and genomic selection with the former being highly appreciated and the latter being viewed with some unease. This is troubling for those who seek genomic selection implementation in Alberta as advocates largely view genomic selection as an informational tool to aid in tree breeding. Why this distinction exists was not abundantly clear in this study. Many explanations are possible, such as negative connotations associated with the term genomics and how genomic selection can be seen as new, although this was not always the case as demonstrated. Another possible reason was expressed in an interesting narrative about the role of increasing information that humans have at their disposal when making decisions in natural areas. This was prompted by those who felt that the increased accuracy in picking desirable traits that genomic selection provides had the potential to decrease the diversity of forests. One participant touched on this when speaking about tree breeding:

> So, there should still be a diversity of the good and the bad and the ugly. Like the forest needs the good, the bad, and the ugly. Right? I don't know I think where it is at it's alright. I don't know. I don't know. Maybe in a thousand years we'll be custom breeding everything for cutblocks on the side of that mountain and on the side of that mountain, but right now it's not there and I think it is okay. There's enough **randomness** [bold added] still there that it will still be pretty natural forests. (3.7).

This partially explains some differences between tree breeding and genomic selection with genomic selection possibly being viewed as reducing the 'randomness' that contributes to a healthy ecosystem. In this way, increased accuracy at picking desirable traits had the potential to backfire for some participants. This follows what Pidgeon *et al*. (2012) found when it comes to perceptions about geoengineering and its role within environments, with humans having increasing control over nature presenting ethical concerns. Throughout this paper it became clear that the use of genomic selection in forestry did not always align with participants' ideas of sustainable forest management and for what they considered as natural. Technologies that are perceived as more natural are typically more acceptable (Sjöberg, 2004). Genomic selection was found to contain characteristics of dread, unknown, and unnatural qualities.

Attempts at communicating the risks or lack thereof of highly complex technologies remains a challenge. One of these challenges, as Pidgeon, Harthorn, and Satterfield (2011) point out, is "that emerging technologies bring very different requirements for risk communication—not least because hypothetical uncertainties and data gaps, rather than empirically observed risks, are often the dominant considerations" (p.1698). The results in this study suggest genomic selection application in forestry goes beyond simple rejection or acceptance and participants are willing to accept some risk. With climate change and the associated uncertainty of future forest conditions, is genomic selection a tool to help forests become more flexible or does it exacerbate that uncertainty? On this point stakeholders held a plurality of views, often contingent upon how genomic selection will be used. As such, two questions were raised and would do much if kept in mind during any risk communication efforts when approaching stakeholders: how are tree breeders maintaining diversity while selecting desirable traits and how much improved genetic stock on FMA areas is too much? When approaching publics with genomic selection, this study firmly counters efforts to treat the risk concerns of publics as "irrational," as others have done in the GMO debate (for an overview see Marris, 2001). The risks expressed by these participants are certainly real and relevant to the variety of stakeholders interviewed and therefore, should be treated as such by policy makers as risk is subjective. To do otherwise gives openings for future conflict that may otherwise be avoided. When approaching publics with genomic selection, how it is framed may prove critical in reception. Framing similar emergent technologies, as Schütz and Wiedemann (2008) have shown with nanotechnology, can have significant effects on risk perception. Moving forward, framing genomic selection so that it is viewed as aligning with natural processes rather than opposing or controlling nature may help gather greater positive responses. Moreover, contextually framing genomic selection within a growing climate crisis may sway public opinion in that benefits go beyond industrial purposes, but as shown here, not everyone will be convinced of these adaptation benefits.

## Conclusion

There was some risk that was found to be associated with genomic selection. It was seen as controversial, with unintended consequences which are often delayed, and sometimes seen as using science that was inconclusive. Moreover, genomic selection had many wondering if this was appropriate in forest ecosystems. While some were supportive of the benefits, others questioned how realistic it is to expect this technology to produce forests that are more resilient and adaptive to climate change. Some of the risks that were expressed ran counter to what experts were hoping to accomplish through the implementation of genomic selection. The many risks stated in this study were not unexpected given the parallels in risk perception of biotechnology in agricultural literature. However, unlike agriculture, forestry has long rotations often a century in length. For an agricultural crop to reach maturity, be harvested, and replanted involves a much shorter timeframe than what a tree would take. Therefore, the risks of employing a technology in forestry was viewed as having greater potential for uncertainty due to a longer period of time to determine if delayed effects occur over the course of a tree's lifecycle and subsequent generations. The risks discussed here indicate the intricate nature of risk perception and for some the risks associated with genomic selection are neither ethical nor fair, and are surrounded by uncertainty. Uncertainty due to the technology itself certainly, but also due to forestry and its long rotations.

"I don't see a problem with 30% or 20% or- But, if we were to say a 100% wholesale… we're going to do it across the whole landscape with all these species and then I would just be concerned what a hundred years from now would look like. Cause that's the problem with forestry it takes a long period of time to learn from our mistakes." (1.5).

## References


Alhakami, A. S., & Slovic, P. (1994). A psychological study of the inverse relationship between perceived risk and perceived benefit. *Risk Analysis*, *14*(6), 1085-1096. doi:10.1111/j.1539-6924.1994.tb00080.x

Armaş, I., & Avram, E. (2008). Patterns and trends in the perception of seismic risk. Case study: Bucharest Municipality/Romania. *Natural Hazards*, *44*(1), 147-161. doi:10.1007/s11069-007-9147-9

Beck, U. (1992). *Risk society: towards a new modernity.* London: Sage.

Blok, A., Jensen, M., & Kaltoft, P. (2008). Social identities and risk: expert and lay imaginations on pesticide use. *Public Understanding of Science*, *17*(2), 189-209. doi:10.1077/0963662506070176

De Groot, J. I., Steg, L., & Poortinga, W. (2013). Values, perceived risks and benefits, and acceptability of nuclear energy. *Risk Analysis: An International Journal*, *33*(2), 307-317. doi:10.1111/j.1539-6924.2012.01845.x.

Dohle, S., Keller, C., & Siegrist, M. (2010). Examining the relationship between affect and implicit associations: Implications for risk perception. *Risk Analysis: An International Journal*, *30*(7), 1116-1128. doi:10.1111/j.1539-6924.2010.01404.x

Douglas, M., & Wildavsky, A. (1983). *Risk and culture: An essay on the selection of technological and environmental dangers*. https://www.ucpress.edu/book/9780520050631/risk-and-culture

El-Kassaby, Y. A., Klápště, J., & Guy, R. D. (2012). Breeding without breeding: selection using the genomic best linear unbiased predictor method (GBLUP). *New Forests*, *43*(5-6), 631-637. doi:10.1007/s11056-012-9338-4

Finucane, M. L., & Holup, J. L. (2005). Psychosocial and cultural factors affecting the perceived risk of genetically modified food: an overview of the literature. *Social Science and Medicine*, *60*(7), 1603-1612. doi:10.1016/j.socscimed.2004.08.007

Flynn, R., Bellaby, P., Ricci, M., (2006). Risk perception of an emergent technology: the case of hydrogen energy. Forum: Qualitative Social Research, 7, 1, Article 19: http://www.qualitative-research.net/fqs-texte/1-06/06-1-19-e.htmS. Accessed: May 16, 2019

Gaskell, G., Allum, N., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., & Bardes, J. (2004). GM foods and the misperception of risk perception. *Risk Analysis: An International Journal*, *24*(1), 185-194. doi:10.1111/j.0272-4332.2004.00421.x

Grattapaglia, D. (2017). Status and perspectives of genomic selection in forest tree breeding. In Varshney, R.K., Roorkiwal, M., & Sorrells, M. E. (Eds.), *Genomic Selection for Crop Improvement: New Molecular Breeding Strategies for Crop Improvement* (pp. 199-249). doi:10.1007/978-3-319-63170-7_9

Grattapaglia, D., & Resende, M. D. (2011). Genomic selection in forest tree breeding. *Tree Genetics & Genomes*, *7*(2), 241-255. doi:10.1007/s11295-010-0328-4

Gupta, N., Fischer, A. R., & Frewer, L. J. (2012). Socio-psychological determinants of public acceptance of technologies: a review. *Public Understanding of Science*, *21*(7), 782-795. doi:10.1177/0963662510392485

Hajjar, R., McGuigan, E., Moshofsky, M., & Kozak, R. A. (2014). Opinions on strategies for forest adaptation to future climate conditions in western Canada: surveys of the general public and leaders of forest-dependent communities. *Canadian Journal of Forest Research*, *44*(12), 1525-1533. doi:10.1139/cjfr-2014-0142

Hansen, J., Holm, L., Frewer, L., Robinson, P., & Sandøe, P. (2003). Beyond the knowledge deficit: Recent research into lay and expert attitudes to food risks. *Appetite*, *41*(2), 111-121. doi:10.1016/S0195-6663(03)00079-5

Herrick, C.B. (2005). 'Cultures of GM': discourses of risk and labelling of GMOs in the UK and EU. *Area 37* (3), 286–294. doi:10.1111/j.1475-4762.2005.00632.x

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., ... & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, *8*(2), 177-187. doi:10.1111/j.1539-6924.1988.tb01168.x

Kelly, E. C., & Bliss, J. C. (2009). Healthy forests, healthy communities: an emerging paradigm for natural resource-dependent communities? *Society and Natural Resources*, *22*(6), 519-537. doi:10.1080/08941920802074363

Krimsky, S., & Golding, D. (1992). *Social theories of risk.* Westport, CT: Praeger Publishing Company.

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic Change*, *77*(1-2), 45-72. doi:10.1007/s10584-006-9059-9

Marris, C. (2001). Public views on GMOs: deconstructing the myths. *EMBO Reports*, *2*(7), 545-548. doi:10.1093/embo-reports/kve142

Pidgeon, N., Corner, A., Parkhill, K., Spence, A., Butler, C., & Poortinga, W. (2012). Exploring early public responses to geoengineering. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 370*, 4176-4196. doi:10.1098/rsta.2012.0099

Pidgeon, N., Harthorn, B., & Satterfield, T. (2011). Nanotechnology risk perceptions and communication: emerging technologies, emerging challenges. *Risk Analysis: An International Journal*, *31*(11), 1694-1700. doi:10.1111/j.1539-6924.2011.01738.x

Pidgeon, N., & Rogers-Hayden, T. (2007). Opening up nanotechnology dialogue with the publics: risk communication or 'upstream engagement'? *Health, Risk & Society, 9*(2), 191-210. doi:10.1080/13698570701306906

Renn, O. (1998). Three decades of risk research: accomplishments and new challenges. *Journal of Risk Research*, *1*(1), 49-71. doi:10.1080/136698798377321

Renn, O. (2008). *Risk Governance: Coping with Uncertainty in a Complex World*. doi:10.4324/9781849772440

Richardson, D.M., Rundel, P.W., Jackson, S.T., Teskey, R.O., Aronson, J., Bytnerowicz, A., Wingfield, M.J. & Proches¸, S. (2007). Human impacts in pine forests: past, present and future. *Annual Reviews of Ecology, Evolution, and Systematics*, *38*, 275–297. doi:10.1146/annurev.ecolsys.38.091206.095650

Rippl, S. (2002). Cultural theory and risk perception: a proposal for a better measurement. *Journal of Risk Research*, *5*(2), 147–165. doi:10.1080/13669870110042598

Satterfield, T., Kandlikar, M., Beaudrie, C. E., Conti, J., & Harthorn, B. H. (2009). Anticipating the perceived risk of nanotechnologies. *Nature Nanotechnology*, *4*(11), 752-758. doi:10.1038/nnano.2009.265

Schütz, H., & Wiedemann, P. M. (2008). Framing effects on risk perception of nanotechnology. *Public Understanding of Science*, *17*(3), 369-379. doi:10.1177/0963662506071282

Shaw, A. (2002). "It just goes against the grain." Public understandings of genetically modified (GM) food in the UK. *Public Understanding of Science*, *11*(3), 273-291. doi:10.1088/0963-6625/11/3/305

Siegrist, M. (2000). The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. *Risk Analysis*, *20*(2), 195-204. doi:10.1111/0272-4332.202020

Siegrist, M., Cvetkovich, G., & Roth, C. (2000). Salient value similarity, social trust, and risk/benefit perception. *Risk Analysis*, *20*(3), 353-362. doi:10.1111/0272-4332.203034

Simons, J., Zimmer, R., Vierboom, C., Härlen, I., Hertel, R., & Böl, G. F. (2009). The slings and arrows of communication on nanotechnology. *Journal of Nanoparticle Research*, *11*(7), 1555-1571. doi:10.1007/s11051-009-9653-7

Sjöberg, L. (2000). Factors in risk perception. *Risk Analysis*, *20*(1), 1-12. doi:10.1111/0272-4332.00001

Sjöberg, L. (2004). Principles of risk perception applied to gene technology. *EMBO Reports*, *5*(1S), S47-S51. doi:10.1038/sj.embor.7400258

Slovic, P. (1987). Perception of risk. *Science*, *236*, 280-285. doi:10.1126/science.3563507

Slovic, P. (1996). Perception of risk from radiation. *Radiation Protection Dosimetry*, *68*(3-4), 165-180. doi:10.1093/oxfordjournals.rpd.a031860

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1982). Why study risk perception? *Risk Analysis*, *2*(2), 83-93. doi:10.1111/j.1539-6924.1982.tb01369.x

Sudman, S., & Kalton, G. (1986). New developments in the sampling of special populations. *Annual Review of Sociology*, *12*(1), 401-429. doi:10.1146/annurev.so.12.080186.002153

Touili, N., Baztan, J., Vanderlinden, J. P., Kane, I. O., Diaz-Simal, P., & Pietrantoni, L. (2014). Public perception of engineering-based coastal flooding and erosion risk mitigation options: Lessons from three European coastal settings. *Coastal Engineering*, *87*, 205-209. doi:10.1016/j.coastaleng.2014.01.004

Vasvári, T. (2015). Risk, risk perception, risk management–a review of the literature. *Public Finance Quarterly*, *60*(1), 29-48. Available from https://econpapers.repec.org/article/pfqjournl/v_3a60_3ay_3a2015_3ai_3a1_3ap_3a29-48.htm. Accessed: July 8, 2019

# Chapter 4: Conclusion

This conclusion offers a brief overview of the study, the applicability of the results beyond the participants sampled here, a few recommendations for those interested in introducing genomic selection to forest management in Alberta, and suggested future areas of research. Some of the present and future challenges that face the forestry sector were examined in this thesis. I explored the complex environment of Alberta's forests and some stakeholders who engage on that landscape. In addition, I examined how a sample of engaged stakeholders in two forest-based communities value forests and the various relationships participants had with these landscapes, how they perceive disturbances on these landscapes, as well as their views regarding the use of genomics in tree breeding, and the risk characteristics they assign to genomic selection. Examining these areas revealed potential conflicts between and within stakeholder groups. While the two main chapters in my thesis deal with different topics they both illuminate how forest management has the potential to be critically received based on stakeholder perceptions. Chapter 2 tackles large issues such as multiple users who hold a plurality of values on a threatened landscape. Alternatively, Chapter 3 takes a narrower look by examining the potential implementation of a specific technology.

Forest policy and management decisions can have large consequences on the many communities and publics of Alberta. Managing for all values and all groups such that every group is satisfied is of course an impossible task, given that trade-offs must be made. Deciding how to achieve the many goals of forest management and in what capacity, choices that can affect public opinion towards forestry operations are made. It can also be disheartening to see the vast swaths of red and grey that predominate areas of the Albertan landscape. But why is this happening? What or who is to blame? Are these events manageable and avoidable? And while mountain pine beetle and fires may present visible, causal agents, it is less certain whether they are seen as the driving forces or just consequences of larger mechanisms. In the face of these events, communities, industries, and governments face massive challenges to maintaining forest values.

Chapter 2 offers an initial, broad look into how a sample of engaged stakeholders in two forest-based communities, where genomic selection may be introduced, value forests and perceive various forest disturbances. As well, it provides a discussion of how various values impact management decision-making preferences on a landscape rife with many forms of disturbance and where tough decisions have to be made. These findings contribute to a broad field of study on human dimensions in natural resource management. Moreover, this study contributes to discussions about sustainable and ecosystem-based management approaches to maintaining societal values. Since the sample is not representative it is worthwhile to discuss the generalizability of the results. For instance, the findings regarding forest values discussed in this study, while likely to be expressed by members of other groups, do not capture the values or perspectives held by more biocentric individuals or nonconsumptive recreationists. The reasons, furthermore, why some values are seen to be prioritized over others is population and location specific. For example, the reason why snowmobilers viewed their trails as being less of a priority than harvesting is contextually dependent.

On the other hand, we have no reason to presume that the finding that perceived value prioritizations influenced reception towards management decisions would be sample dependent. Additional findings may also be considered to be potentially generalizable beyond the study sample, including the finding that both highly subjective terms and personal evaluations of forest conditions can lead to disagreements amongst stakeholders. This is likely true for populations outside of the sample, although the many definitions of those terms presented here do not represent all interpretations. Finally, the results of the study found a link between perceptions of disturbance and participants' views of management activities, that may suggest a general association between personal perceptions of disturbance, and support for different management activities, although again, the many ways in which people understand disturbances such as fire, mountain pine beetle, and climate change is not fully presented in this study.

Chapter 3 highlights the risk characteristics that the sample assigned to genomic selection. Being one of the first risk perception studies of genomic selection application in tree breeding, it was important to substantiate how engaged stakeholders might perceive this emergent technology if adoption were to occur. This study contributes to the growing body of literature surrounding new technologies and risk perceptions. As with the findings presented in Chapter 2, given the non-representative nature of the sample, some results must be treated with caution as they can be expected to be sample-specific, while other findings are less so. While participants were aware of tree breeding, they were less aware of genomic selection. While certainly having some concerns, most participants in the sample did not completely reject the use of genomic selection in tree breeding and were willing to accept certain, limited applications. The level of awareness and cautiously positive reception towards tree breeding and genomic selection expressed by the participants in this study should not be used to indicate awareness or reception of other citizens or publics, given the small sample size, and sampling strategy. Concerns expressed toward genomic selection in this sample were similar to findings in other studies focused on concerns expressed toward biotechnologies used in agriculture. Principally, interview participants attributed to genomic selection several unknown characteristics such as: uncontrollability, unintended outcomes, and delayed effects. Moreover, genomic selection did not always align with personal views regarding natural forests, and many respondents expressed concern about potential reductions in genetic diversity. Genomic selection was viewed as an unnatural technology among some participants, but for others it was a nonissue. In addition, not all interviewees identified genomic selection as a new technology as there were some who made references to its past use in agriculture and thus, genomic selection was less unknown to those participants. The main characteristics associated with genomic selection expressed by the participants in this study suggest that others would also share some of these concerns. However, it is not expected that every individual will perceive all of these themes mentioned nor are the themes identified in this study likely to be exhaustive.

For those seeking to implement genomic selection in Alberta, several recommendations are informed by this research. Firstly, the results in this study indicate a general lack of communication and engagement in some instances in forest management and tree breeding specifically. Greater communication regarding how the forest is managed as a genetic resource could potentially alleviate some of the concerns for genetic diversity identified in this study. This involvement could be, for instance, tours or workshops at orchard locations. Secondly, to bridge the gap between expert and lay notions of risk, trust may play an important role. Trust, however, is not built easily or quickly. Better communication could also facilitate building that trust.

There are also more specific and immediate recommendations. For example, the results demonstrated that those currently working in the forestry sector wanted to see models which are validated. Approaching individuals with forestry experience in these communities' calls for transparency in how these models are built and validated. In addition, the results suggest that presenting genomic selection as a set of tools that are associated with a long history of research and application, particularly in agriculture, and also articulating what is new—and not new—with respect to conventional breeding practices, may be beneficial as a means to better situate the presumed novelty of proposed activities.

This study also identified that not all participants were accepting of the benefits of genomic selection. As such, it is recommended not to overstate the benefits of genomic selection to the citizens of these communities nor present genomic selection as a solution to global challenges. Not all stakeholders in this study were concerned about global issues such as climate change, however, all participants were concerned about localized forest issues and contextualizing genomic selection within those current issues may prove more useful when communicating with stakeholders. As previously mentioned, transparency and communicating about the amount of work that is put into creating and validating these models may alleviate some concerns, but certainly not all. It is worth acknowledging to communities of interest that there is some uncertainty associated with genomic selection, as is true for most forest management activities. Given that participants in this study have had opportunities to experience first hand the unintended effects of past management activities, their sensitivity to uncertainty is both understandable, and warrants heeding with a precautionary approach to the introduction of new tree breeding and broader forest management strategies.

I suggest that future research expands upon these lines of inquiry into public perceptions of genomic selection in tree breeding with broader cross sections of forest management stakeholders, and the inclusion of other areas of the province, and other provinces. Examining how perception might change over time as genomic selection becomes more prevalent in terms of implementation or in the media may also be illuminating. Furthermore, understanding the amount of genetically improved stock versus naturally regenerated stands that is acceptable on a landscape is an increasingly important question to ask publics. I would also suggest that while this study generally examines large scale events and technology implementation separately, more work should focus on how perceptions of climatically driven disturbances influence not only perceptions of new technologies, but also other forest management decisions. I'm optimistic that greater collaboration efforts can exist between stakeholder groups to come closer to an agreeable forest management concept and to help determine what part genomics has to play.

# References

Adamowicz, W.L., and Burton, P.J. (2003). Sustainability and sustainable forest management. Chapter 2. In P.J. Burton, C. Messier, D.W. Smith, and W.L. Adamowicz (Eds.), *Towards Sustainable Management of the Boreal Forest* (pp.41-64). doi:10.1139/9780660187624

Alberta Forest Products Association and Alberta Sustainable Resource Development. (2008). *Economic impact of the Alberta forest industry*. Available from: http://www.assembly.ab.ca/lao/library/egovdocs/2008/alsrd/167559.pdf. Accessed: September 15, 2019

Alhakami, A. S., & Slovic, P. (1994). A psychological study of the inverse relationship between perceived risk and perceived benefit. *Risk Analysis*, *14*(6), 1085-1096. doi:10.1111/j.1539-6924.1994.tb00080.x

Allen, S. D., Wickwar, D. A., Clark, F. P., Dow, R. R., Potts, R., & Snyder, S. A. (2009). *Values, beliefs, and attitudes technical guide for Forest Service land and resource management, planning, and decision-making*. doi:10.2737/PNW-GTR-788

Armaş, I., & Avram, E. (2008). Patterns and trends in the perception of seismic risk. Case study: Bucharest Municipality/Romania. *Natural Hazards*, *44*(1), 147-161. doi:10.1007/s11069-007-9147-9

Bawa, R. S. (2017). Effects of wildfire on the value of recreation in western North America. *Journal of Sustainable Forestry*, *36*(1), 1-17. doi:10.1080/10549811.2016.1233503

Beck, U. (1992). *Risk society: towards a new modernity.* London: Sage.

Beckley, T. M., Boxall, P. C., Just, L. K., & Wellstead, A. M. (1999). Forest stakeholder attitudes and values: selected social-science contributions. Canadian Forest Service, Northern Forestry Centre, Edmonton, AB. Available from: http://publications.gc.ca/site/archivee-archived.html?url=http://publications.gc.ca/collections/Collection/Fo46-12-362E.pdf. Accessed: August, 20, 2019

Bengston, D. N., Webb, T. J., & Fan, D. P. (2004). Shifting forest value orientations in the United States, 1980-2001: A computer content analysis. *Environmental Values*, *13*(3), 373-392. doi:10.3197/096327104323312734

Blok, A., Jensen, M., & Kaltoft, P. (2008). Social identities and risk: expert and lay imaginations on pesticide use. *Public Understanding of Science*, *17*(2), 189-209. doi:10.1077/0963662506070176

Brown, T. C. (1984). The concept of value in resource allocation. *Land Economics*, *60*(3), 231-246. doi:10.2307/3146184

Brown, G., & Reed, P. (2000). Validation of a forest values typology for use in national forest planning. *Forest Science*, *46*(2), 240-247. doi:10.1093/forestscience/46.2.240

The Canadian Boreal Forest Agreement. (2015). Towards a Natural Range of Variation (NRV) Strategy for the Canadian Boreal Forest Agreement - Summary Report. 1-15. Available from https://www.fpac.ca/innovative-new-commitment-to-natural-landscapes-in-canadian-boreal-forest/ Accessed: October 15, 2019

Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., & Upham, P. (2015). International trends in public perceptions of climate change over the past quarter century. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(1), 35-61. doi:10.1002/wcc.321

Carolan, M., & Stuart, D. (2016). Get real: climate change and all that 'it'entails. *Sociologia Ruralis*, *56*(1), 74-95. doi:10.1111/soru.12067

Certification Canada. (2019). *Forest Management Certification Canada 2018 Year-End Status Report Alberta*. Available from http://certificationcanada.org/en/statistics/provincial-statistics/. Accessed: January 14, 2020

Cheveau, M., Imbeau, L., Drapeau, P., & Bélanger, L. (2008). Current status and future directions of traditional ecological knowledge in forest management: a review. *The Forestry Chronicle, 84*(2), 231-243. doi:10.5558/tfc84231-2

Choy, L. T. (2014). The strengths and weaknesses of research methodology: comparison and complimentary between qualitative and quantitative approaches. *IOSR Journal of Humanities and Social Science*, *19*(4), 99-104. doi:10.9790/0837-194399104

Cohen, N., & Arieli, T. (2011). Field research in conflict environments: Methodological challenges and snowball sampling. *Journal of Peace Research, 48*(4), 423-435. doi:10.1177/0022343311405698

Cubbage, F., Harou, P., & Sills, E. (2007). Policy instruments to enhance multi-functional forest management. *Forest Policy and Economics*, *9*(7), 833-851. doi:10.1016/j.forpol.2006.03.010

Dale, V. H., Joyce, L. A., McNulty, S., Neilson, R. P., Ayres, M. P., Flannigan, M. D., ... & Simberloff, D. (2001). Climate change and forest disturbances: climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. *BioScience*, *51*(9), 723-734. doi:10.1641/0006-3568(2001)051[0723:CCAFD]2.0.CO;2

Davidson, D. J., Williamson, T., & Parkins, J. R. (2003). Understanding climate change risk and vulnerability in northern forest-based communities. *Canadian Journal of Forest Research*, *33*(11), 2252-2261. doi:10.1139/X03-138

De Groot, J. I., Steg, L., & Poortinga, W. (2013). Values, perceived risks and benefits, and acceptability of nuclear energy. *Risk Analysis: An International Journal*, *33*(2), 307-317. doi:10.1111/j.1539-6924.2012.01845.x.

Demski, C., Capstick, S., Pidgeon, N., Sposato, R. G., & Spence, A. (2017). Experience of extreme weather affects climate change mitigation and adaptation responses. *Climatic Change*, *140*(2), 149-164. doi:10.1007/s10584-016-1837-4

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., ... & Bartuska, A. (2015). The IPBES Conceptual Framework—connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1-16. doi:10.1016/j.cosust.2014.11.002

Dietz, T., Fitzgerald, A., & Shwom, R. (2005). Environmental values. *Annual Review of Environment and Resources*, *30*, 335-372. doi:10.1146/annurev.energy.30.050504.144444

Dohle, S., Keller, C., & Siegrist, M. (2010). Examining the relationship between affect and implicit associations: Implications for risk perception. *Risk Analysis: An International Journal*, *30*(7), 1116-1128. doi:10.1111/j.1539-6924.2010.01404.x

Douglas, M., & Wildavsky, A. (1983). *Risk and culture: An essay on the selection of technological and environmental dangers*. https://www.ucpress.edu/book/9780520050631/risk-and-culture

Driscoll, D. (2019). Assessing Sociodemographic Predictors of Climate Change Concern, 1994–2016. *Social Science Quarterly (Wiley-Blackwell)*, *100*(5), 1699–1708. doi:10.1111/ssqu.12683

Dunlap, R. E. (2013). Climate change skepticism and denial: An introduction. *American Behavioral Scientist*, *57*(6), 691-698. doi:10.1177/0002764213477097

Dunlap, R. E., & McCright, A. M. (2008). A widening gap: Republican and Democratic views on climate change. *Environment: Science and Policy for Sustainable Development*, *50*(5), 26-35. doi:10.3200/ENVT.50.5.26-35

El-Kassaby, Y. A., Isik, F., & Whetten, R. W. (2014). Modern advances in tree breeding. In Fenning, T. (Eds.) *Challenges and Opportunities for the World's Forests in the 21st Century* (pp. 441-459). doi:10.1007/978-94-007-7076-8_18

El-Kassaby, Y. A., Klápště, J., & Guy, R. D. (2012). Breeding without breeding: selection using the genomic best linear unbiased predictor method (GBLUP). *New Forests*, *43*(5-6), 631-637. doi:10.1007/s11056-012-9338-4

Failing, L., & Gregory, R. (2003). Ten common mistakes in designing biodiversity indicators for forest policy. *Journal of Environmental Management*, *68*(2), 121-132. doi:10.1016/S0301-4797(03)00014-8

Finucane, M. L., & Holup, J. L. (2005). Psychosocial and cultural factors affecting the perceived risk of genetically modified food: an overview of the literature. *Social Science and Medicine*, *60*(7), 1603-1612. doi:10.1016/j.socscimed.2004.08.007

Flynn, R., Bellaby, P., Ricci, M., (2006). Risk perception of an emergent technology: the case of hydrogen energy. Forum: Qualitative Social Research, 7, 1, Article 19: http://www.qualitative-research.net/fqs-texte/1-06/06-1-19-e.htmS. Accessed: May 16, 2019

Food and Agriculture Organization of the United Nations (FAO). (2016). *Planted Forests*. Available from http://www.fao.org/forestry/plantedforests/en/. Accessed: June 1, 2019

Frewer, L. J., Howard, C., & Shepherd, R. (1997). Public concerns in the United Kingdom about general and specific applications of genetic engineering: Risk, benefit, and ethics. *Science, Technology, & Human Values*, *22*(1), 98-124. doi:10.1177/016224399702200105

García-Ruiz, A., Cole, J. B., VanRaden, P. M., Wiggans, G. R., Ruiz-López, F. J., & Van Tassell, C. P. (2016). Changes in genetic selection differentials and generation intervals in US Holstein dairy cattle as a result of genomic selection. *Proceedings of the National Academy of Sciences*, *113*(28), E3995-E4004. doi:10.1073/pnas.1519061113

Gaskell, G., Allum, N., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., & Bardes, J. (2004). GM foods and the misperception of risk perception. *Risk Analysis: An International Journal*, *24*(1), 185-194. doi:10.1111/j.0272-4332.2004.00421.x

Genome Canada. (n.d.). $GE^3LS$ Research. Available from https://www.genomecanada.ca/en/programs/ge3ls-research. Accessed: September 8, 2019

Goodfellow, M. J., Williams, H. R., & Azapagic, A. (2011). Nuclear renaissance, public perception and design criteria: An exploratory review. *Energy Policy*, *39*(10), 6199-6210. doi:10.1016/j.enpol.2011.06.068

Government of Alberta. (2015). Sustainable Forest Management 2015 Facts & Statistics Sheets- Reforesting Harvested Areas. Available from https://www.alberta.ca/sustainable-forest-management-statistics.aspx. Accessed: June 3, 2019

Government of Alberta. (2017). Annual Status of Reforestation in Alberta Report 2016. Available from https://open.alberta.ca/publications/annual-status-of-reforestation-in-alberta-report#summary. Accessed: June 3, 2019

Government of Alberta. (2019). Forest management agreements. Available from https://www.alberta.ca/forest-management-agreements.aspx. Accessed: August 23, 2019

Grattapaglia, D. (2017). Status and perspectives of genomic selection in forest tree breeding. In Varshney, R.K., Roorkiwal, M., & Sorrells, M. E. (Eds.), *Genomic Selection for Crop Improvement: New Molecular Breeding Strategies for Crop Improvement* (pp. 199-249). doi:10.1007/978-3-319-63170-7_9

Grattapaglia, D., & Resende, M. D. (2011). Genomic selection in forest tree breeding. *Tree Genetics & Genomes*, *7*(2), 241-255. doi:10.1007/s11295-010-0328-4

Grattapaglia, D., Silva-Junior, O. B., Resende, R. T., Cappa, E. P., Müller, B. S., Tan, B., ... & El-Kassaby, Y. A. (2018). Quantitative genetics and genomics converge to accelerate forest tree breeding. *Frontiers in Plant Science, 9*(1693), 1-10. doi:10.3389/fpls.2018.01693

Gupta, N., Fischer, A. R., & Frewer, L. J. (2012). Socio-psychological determinants of public acceptance of technologies: a review. *Public Understanding of Science*, *21*(7), 782-795. doi:10.1177/0963662510392485

Hajjar, R., McGuigan, E., Moshofsky, M., & Kozak, R. A. (2014). Opinions on strategies for forest adaptation to future climate conditions in western Canada: surveys of the general public and leaders of forest-dependent communities. *Canadian Journal of Forest Research*, *44*(12), 1525-1533. doi:10.1139/cjfr-2014-0142

Hansen, J., Holm, L., Frewer, L., Robinson, P., & Sandøe, P. (2003). Beyond the knowledge deficit: Recent research into lay and expert attitudes to food risks. *Appetite*, *41*(2), 111-121. doi:10.1016/S0195-6663(03)00079-5

Herrick, C.B. (2005). 'Cultures of GM': discourses of risk and labelling of GMOs in the UK and EU. *Area 37* (3), 286–294. doi:10.1111/j.1475-4762.2005.00632.x

Homer, P. M., & Kahle, L. R. (1988). A structural equation test of the value-attitude-behavior hierarchy. *Journal of Personality and Social Psychology*, *54*(4), 638-646. doi:10.1037/0022-3514.54.4.638

Hull, R. B., Richert, D., Seekamp, E., Robertson, D., & Buhyoff, G. J. (2003). Understandings of environmental quality: ambiguities and values held by environmental professionals. *Environmental Management, 31*(1), 1-13. doi:10.1007/s00267-002-2812-6

Hull, R.B., & Robertson, D.P. (2000). The language of nature matters: we need a more public ecology. In: Gobster, P., Hull, R.B. (Eds.), *Restoring Nature: Perspectives from the Social Sciences and Humanities* (pp. 97–118). Available from: https://www.fs.usda.gov/treesearch/pubs/12560. Accessed July 5, 2019

Isik, F. (2014). Genomic selection in forest tree breeding: the concept and an outlook to the future. *New Forests, 45*(3), 379-401. doi:10.1007/s11056-014-9422-z

Ives, C. D., & Kendal, D. (2014). The role of social values in the management of ecological systems. *Journal of Environmental Management*, *144*, 67-72. doi:10.1016/j.jenvman.2014.05.013

Jamal, T., & Stronza, A. (2009). Collaboration theory and tourism practice in protected areas: Stakeholders, structuring and sustainability. *Journal of Sustainable Tourism*, *17*(2), 169-189. doi:10.1080/09669580802495741

Jones, N., Shaw, S., Ross, H., Witt, K., & Pinner, B. (2016). The study of human values in understanding and managing social-ecological systems. *Ecology and Society*, *21*(1), 294-303. doi:10.5751/ES-07977-210115

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., ... & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, *8*(2), 177-187. doi:10.1111/j.1539-6924.1988.tb01168.x

Kauffman, J. B. (2004). Death rides the forest: perceptions of fire, land use, and ecological restoration of western forests. *Conservation Biology*, *18*(4), 878-882. doi:10.1111/j.1523-1739.2004.545_1.x

Keenan, R. J. (2015). Climate change impacts and adaptation in forest management: a review. *Annals of Forest Science*, *72*(2), 145-167. doi:10.1007/s13595-014-0446-5

Kelly, E. C., & Bliss, J. C. (2009). Healthy forests, healthy communities: an emerging paradigm for natural resource-dependent communities? *Society and Natural Resources*, *22*(6), 519-537. doi:10.1080/08941920802074363

Koerber, A., & McMichael, L. (2008). Qualitative sampling methods: A primer for technical communicators. *Journal of Business and Technical Communication*, *22*(4), 454-473. doi:10.1177/1050651908320362

Kolström, M., Lindner, M., Vilén, T., Maroschek, M., Seidl, R., Lexer, M. J., ... & Marchetti, M. (2011). Reviewing the science and implementation of climate change adaptation measures in European forestry. *Forests*, *2*(4), 961-982. doi:10.3390/f2040961

Krimsky, S., & Golding, D. (1992). *Social theories of risk.* Westport, CT: Praeger Publishing Company.

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic Change*, *77*(1-2), 45-72. doi:10.1007/s10584-006-9059-9

Lenz, P. R., Beaulieu, J., Mansfield, S. D., Clément, S., Desponts, M., & Bousquet, J. (2017). Factors affecting the accuracy of genomic selection for growth and wood quality traits in an advanced-breeding population of black spruce (Picea mariana). *BMC Genomics, 18*(1), 335. doi:10.1186/s12864-017-3715-5

Luckert, M. K., & Williamson, T. (2005). Should sustained yield be part of sustainable forest management? *Canadian Journal of Forest Research*, *35*(2), 356-364. doi:10.1139/X04-172

Lynam, T., De Jong, W., Sheil, D., Kusumanto, T., & Evans, K. (2007). A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management. *Ecology and Society*, *12*(1), 1-15. doi:10.5751/ES-01987-120105

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *AISHE-J: The All Ireland Journal of Teaching and Learning in Higher Education*, *9*(3), 3351-33514. Available from https://ojs.aishe.org/index.php/aishe-j/article/view/335. Accessed: September 3, 2019

Marris, C. (2001). Public views on GMOs: deconstructing the myths. *EMBO Reports*, *2*(7), 545-548. doi:10.1093/embo-reports/kve142

Maxwell, J. A. (2013). *Qualitative research design: an interactive approach*. Third Edition. Thousand Oaks, CA: SAGE Publications.

McCright, A. M., & Dunlap, R. E. (2011). Cool dudes: The denial of climate change among conservative white males in the United States. *Global Environmental Change, 21*(4), 1163-1172. doi:10.1016/j.gloenvcha.2011.06.003

McFarlane, B. L., & Boxall, P. C. (2000). Factors influencing forest values and attitudes of two stakeholder groups: The case of the Foothills Model Forest, Alberta, Canada. *Society & Natural Resources*, *13*(7), 649-661. doi:10.1080/08941920050121927

McFarlane, B. L., & Hunt, L. M. (2006). Environmental activism in the forest sector: Social psychological, social-cultural, and contextual effects. *Environment and Behavior*, *38*(2), 266-285. doi:10.1177/0013916505277999

McFarlane, B. L., Stumpf-Allen, R. C. G., & Watson, D. O. (2006). Public perceptions of natural disturbance in Canada's national parks: the case of the mountain pine beetle (Dendroctonus ponderosae Hopkins). *Biological Conservation*, *130*(3), 340-348. doi:10.1016/j.biocon.2005.12.029

McIntyre, N., Moore, J., & Yuan, M. (2008). A place-based, values-centered approach to managing recreation on Canadian crown lands. *Society and Natural Resources*, *21*(8), 657-670. doi:10.1080/08941920802022297

Messier, C., Puettmann, K., Chazdon, R., Andersson, K. P., Angers, V. A., Brotons, L., ... & Levin, S. A. (2015). From management to stewardship: viewing forests as complex adaptive systems in an uncertain world. *Conservation Letters*, *8*(5), 368-377. doi:10.1111/conl.12156

Meuwissen, T.H., Hayes, B. J., & Goddard, M. E. (2001). Prediction of total genetic value using genome-wide dense marker maps. *Genetics*, *157*(4), 1819-1829. Available from https://www.genetics.org/content/157/4/1819. Accessed: June 20, 2019

Moshofsky, M., Gilani, H. R., & Kozak, R. A. (2019). Adapting forest ecosystems to climate change by identifying the range of acceptable human interventions in western Canada. *Canadian Journal of Forest Research*, *49*(5), 553-564. doi:10.1139/cjfr-2018-0076

Moyer, J. M., Owen, R. J., & Duinker, P. N. (2008). Forest values: A framework for old-growth forest with implications for other forest conditions. *The Open Forest Science Journal*, *1*(1), 27-36. doi:10.2174/1874398600801010027

Muranty, H., Jorge, V., Bastien, C., Lepoittevin, C., Bouffier, L., & Sanchez, L. (2014). Potential for marker-assisted selection for forest tree breeding: lessons from 20 years of MAS in crops. *Tree Genetics & Genomes, 10*(6), 1491-1510. doi:10.1007/s11295-014-0790-5

Myers, T. A., Maibach, E. W., Roser-Renouf, C., Akerlof, K., & Leiserowitz, A. A. (2013). The relationship between personal experience and belief in the reality of global warming. *Nature Climate Change*, *3*(4), 343-347. doi:10.1038/NCLIMATE1754

Namkoong, G., Kang, H. C., & Brouard, J. S. (1988). *Tree breeding: principles and strategies: principles and strategies*. doi:10.1007/978-1-4612-3892-8

Natural Resources Canada. (2018). Sensitivity of communities and regions to forest industry. Available from https://open.canada.ca/data/en/dataset/7e290b03-9555-4dd2-91be-d958136f11bb. Accessed: January 31, 2020

Neale, D. B., & Kremer, A. (2011). Forest tree genomics: growing resources and applications. *Nature Reviews Genetics*, *12*(2), 111-122. doi:10.1038/nrg2931

Nilausen, C., Gélinas, N., & Bull, G. (2016). Perceived acceptability of implementing marker-assisted selection in the forests of British Columbia. *Forests*, *7*(286), 1-19. doi:10.3390/f7110286

Nocentini, S., Buttoud, G., Ciancio, O., & Corona, P. (2017). Managing forests in a changing world – The need for a systemic approach. A Review. *Forest Systems, 26* (1), 1-15. doi:10.5424/fs/2017261-09443

O'Brien, E. A. (2003). Human values and their importance to the development of forestry policy in Britain: a literature review. *Forestry*, *76*(1), 3-17. doi:10.1093/forestry/76.1.3

O'Flaherty, R. M., Davidson-Hunt, I., & Manseau, M. (2008). Indigenous knowledge and values in planning for sustainable forestry: Pikangikum First Nation and the Whitefeather Forest Initiative. *Ecology and Society*, *13*(1), 1-11. doi:10.5751/ES-02284-130106

Oliver, M., Deal, R., Smith, N., Blahna, D., & Kline, J. (2016). What people value: an ecosystem services approach to managing public lands. *Science Findings 188, 1-5. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.* Available from: https://www.fs.usda.gov/treesearch/pubs/52223. Accessed: August 15, 2019

Owen, R. J., Duinker, P. N., & Beckley, T. M. (2009). Capturing old-growth values for use in forest decision-making. *Environmental Management*, *43*(2), 237-248. doi:10.1007/s00267-008-9133-3

Pidgeon, N., Corner, A., Parkhill, K., Spence, A., Butler, C., & Poortinga, W. (2012). Exploring early public responses to geoengineering. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 370*, 4176-4196. doi:10.1098/rsta.2012.0099

Pidgeon, N., Harthorn, B., & Satterfield, T. (2011). Nanotechnology risk perceptions and communication: emerging technologies, emerging challenges. *Risk Analysis: An International Journal*, *31*(11), 1694-1700. doi:10.1111/j.1539-6924.2011.01738.x

Pidgeon, N., & Rogers-Hayden, T. (2007). Opening up nanotechnology dialogue with the publics: risk communication or ‘upstream engagement’? *Health, Risk & Society, 9*(2), 191-210. doi:10.1080/13698570701306906

Rahmstorf, S. (2004). The climate skeptics. In Munich Re (Ed.), *Weather Catastrophes & Climate Change* (pp. 76-83). Available from: http://www.pik-potsdam.de/~stefan/Publications/. Accessed: August 28, 2019

Ratcliffe, B., El-Dien, O. G., Klápště, J., Porth, I., Chen, C., Jaquish, B., & El-Kassaby, Y. A. (2015). A comparison of genomic selection models across time in interior spruce (Picea engelmannii× glauca) using unordered SNP imputation methods. *Heredity, 115*(6), 547-555. doi:10.5061/dryad.m4vh4.

Reed, M. G., Scott, A., Natcher, D., & Johnston, M. (2014). Linking gender, climate change, adaptive capacity, and forest-based communities in Canada. *Canadian Journal of Forest Research*, *44*(9), 995-1004. doi:10.1139/cjfr-2014-0174

Reed, M. G., & Varghese, J. (2007). Gender representation on Canadian forest sector advisory committees. *The Forestry Chronicle*, *83*(4), 515-525. doi:10.5558/tfc83515-4

Renn, O. (1998). Three decades of risk research: accomplishments and new challenges. *Journal of Risk Research*, *1*(1), 49-71. doi:10.1080/136698798377321

Renn, O. (2008). *Risk Governance: Coping with Uncertainty in a Complex World*. doi:10.4324/9781849772440

Resende, M. D., Resende, M. F., Sansaloni, C. P., Petroli, C. D., Missiaggia, A. A., Aguiar, A. M., ... & Pappas, G. J. (2012). Genomic selection for growth and wood quality in Eucalyptus: capturing the missing heritability and accelerating breeding for complex traits in forest trees. *New Phytologist*, *194*(1), 116-128. doi:10.1111/j.1469-8137.2011.04038.x

Resende Jr, M. F. R., Munoz, P., Acosta, J. J., Peter, G. F., Davis, J. M., Grattapaglia, D., ... & Kirst, M. (2012). Accelerating the domestication of trees using genomic selection: accuracy of prediction models across ages and environments. *New Phytologist*, *193*(3), 617-624. doi:10.1111/j.1469-8137.2011.03895.x

Resilient Forests. (2019). RESFOR Home. Available from https://resfor.ualberta.ca/. Accessed: September 8, 2019

Richardson, D.M., Rundel, P.W., Jackson, S.T., Teskey, R.O., Aronson, J., Bytnerowicz, A., Wingfield, M.J. & Proches¸, S. (2007). Human impacts in pine forests: past, present and future. *Annual Reviews of Ecology, Evolution, and Systematics*, *38*, 275–297. doi:10.1146/annurev.ecolsys.38.091206.095650

Rippl, S. (2002). Cultural theory and risk perception: a proposal for a better measurement. *Journal of Risk Research*, *5*(2), 147–165. doi:10.1080/13669870110042598

Satterfield, T., Gregory, R., Klain, S., Roberts, M., & Chan, K. M. (2013). Culture, intangibles and metrics in environmental management. *Journal of Environmental Management*, *117*, 103-114. doi:10.1016/j.jenvman.2012.11.033

Satterfield, T., Kandlikar, M., Beaudrie, C. E., Conti, J., & Harthorn, B. H. (2009). Anticipating the perceived risk of nanotechnologies. *Nature Nanotechnology*, *4*(11), 752-758. doi:10.1038/nnano.2009.265

Schmid-Petri, H., Adam, S., Schmucki, I., & Häussler, T. (2017). A changing climate of skepticism: The factors shaping climate change coverage in the US press. *Public Understanding of Science*, *26*(4), 498-513. doi:10.1177/0963662515612276

Schneider, R. R., Hamann, A., Farr, D., Wang, X., & Boutin, S. (2009). Potential effects of climate change on ecosystem distribution in Alberta. *Canadian Journal of Forest Research*, *39*(5), 1001-1010. doi:10.1139/X09-033

Schütz, H., & Wiedemann, P. M. (2008). Framing effects on risk perception of nanotechnology. *Public Understanding of Science*, *17*(3), 369-379. doi:10.1177/0963662506071282

Semenza, J. C., Hall, D. E., Wilson, D. J., Bontempo, B. D., Sailor, D. J., & George, L. A. (2008). Public perception of climate change: voluntary mitigation and barriers to behavior change. *American Journal of Preventive Medicine*, *35*(5), 479-487. doi:10.1016/j.amepre.2008.08.020

Shaw, A. (2002). "It just goes against the grain." Public understandings of genetically modified (GM) food in the UK. *Public Understanding of Science*, *11*(3), 273-291. doi:10.1088/0963-6625/11/3/305

Siegrist, M. (2000). The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. *Risk Analysis*, *20*(2), 195-204. doi:10.1111/0272-4332.202020

Siegrist, M., Cvetkovich, G., & Roth, C. (2000). Salient value similarity, social trust, and risk/benefit perception. *Risk Analysis*, *20*(3), 353-362. doi:10.1111/0272-4332.203034

Simons, J., Zimmer, R., Vierboom, C., Härlen, I., Hertel, R., & Böl, G. F. (2009). The slings and arrows of communication on nanotechnology. *Journal of Nanoparticle Research*, *11*(7), 1555-1571. doi:10.1007/s11051-009-9653-7

Sjöberg, L. (2000). Factors in risk perception. *Risk Analysis*, *20*(1), 1-12. doi:10.1111/0272-4332.00001

Sjöberg, L. (2004). Principles of risk perception applied to gene technology. *EMBO Reports*, *5*(1S), S47-S51. doi:10.1038/sj.embor.7400258

Slovic, P. (1987). Perception of risk. *Science*, *236*, 280-285. doi:10.1126/science.3563507

Slovic, P. (1996). Perception of risk from radiation. *Radiation Protection Dosimetry*, *68*(3-4), 165-180. doi:10.1093/oxfordjournals.rpd.a031860

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1982). Why study risk perception? *Risk Analysis*, *2*(2), 83-93. doi:10.1111/j.1539-6924.1982.tb01369.x

Sniezko, R. A., & Koch, J. (2017). Breeding trees resistant to insects and diseases: putting theory into application. *Biological Invasions*, *19*(11), 3377-3400. doi:10.1007/s10530-017-1482-5

Statistics Canada. (2017). Whitecourt [Population centre], Alberta and Hinton [Population centre], Alberta (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E. Accessed August 24, 2019

Steel, B. S., List, P., & Shindler, B. (1994). Conflicting values about federal forests: A comparison of national and Oregon publics. *Society & Natural Resources, 7*(2), 137-153. doi:10.1080/08941929409380852

Stejskal, J., Lstibůrek, M., Klápště, J., Čepl, J., & El-Kassaby, Y. A. (2018). Effect of genomic prediction on response to selection in forest tree breeding. *Tree Genetics & Genomes, 14*(5), 1-9. doi:10.1007/s11295-018-1283-8

Stralberg, D., Wang, X., Parisien, M. A., Robinne, F. N., Sólymos, P., Mahon, C. L., ... & Bayne, E. M. (2018). Wildfire-mediated vegetation change in boreal forests of Alberta, Canada. *Ecosphere*, *9*(3), e02156. doi:10.1002/ecs2.2156

Sudman, S., & Kalton, G. (1986). New developments in the sampling of special populations. *Annual Review of Sociology*, *12*(1), 401-429. doi:10.1146/annurev.so.12.080186.002153

Tindall, D. B. (2003). Social values and the contingent nature of public opinion and attitudes about forests. *The Forestry Chronicle*, *79*(3), 692-705. doi:10.5558/tfc79692-3

Touili, N., Baztan, J., Vanderlinden, J. P., Kane, I. O., Diaz-Simal, P., & Pietrantoni, L. (2014). Public perception of engineering-based coastal flooding and erosion risk mitigation options: Lessons from three European coastal settings. *Coastal Engineering, 87*, 205-209. doi:10.1016/j.coastaleng.2014.01.004

Vasvári, T. (2015). Risk, risk perception, risk management–a review of the literature. *Public Finance Quarterly*, *60*(1), 29-48. Available from https://econpapers.repec.org/article/pfqjournl/v_3a60_3ay_3a2015_3ai_3a1_3ap_3a29-48.htm. Accessed: July 8, 2019

Wang, S. (2004). One hundred faces of sustainable forest management. *Forest Policy and Economics*, *6*(3-4), 205-213. doi:10.1016/j.forpol.2004.03.004

Wiggans, G. R., Cole, J. B., Hubbard, S. M., & Sonstegard, T. S. (2017). Genomic selection in dairy cattle: the USDA experience. *Annual Review of Animal Biosciences*, *5*, 309-327. doi:10.1146/annurev-animal-021815-111422

Williamson, T. B., Price, D. T., Beverly, J. L., Bothwell, P. M., Parkins, J. R., Patriquin, M. N., ... & Volney, W. J. A. (2007). *A framework for assessing vulnerability of forest-based communities to climate change*. https://cfs.nrcan.gc.ca/publications?id=27507

Yaffee, S. L. (1999). Three faces of ecosystem management. *Conservation Biology*, *13*(4), 713-725. doi:10.1046/j.1523-1739.1999.98127.x

Zanocco, C., Boudet, H., Nilson, R., Satein, H., Whitley, H., & Flora, J. (2018). Place, proximity, and perceived harm: extreme weather events and views about climate change. *Climatic Change*, *149*(3-4), 349-365. doi:10.1007/s10584-018-2251-x

Zobel, B., & Talbert, J. (1984). *Applied Forest Tree Improvement*. John Wiley & Sons.

# Appendix A: Semi-Structured Interview Guide

1.) First off, I'd just like to get to know who you are. So, tell me a little bit about yourself.
    a. What is your age? How long have you lived in ___?
2.) Tell me about your job? What do you do?
    a. How long? Why this career?
    b. How has this job/forest industry changed from when you first started? Do you think your job will look different in the future? If so, in what ways?
3.) What kind of outdoor activities do you like to participate in? How do you choose a location?
    a. Along those same lines, what (if any) activities do you do in a forest? What do you appreciate when doing those activities in that environment?
    b. Have you experienced any difficulties that prevent you from participating or enjoying these activities?
4.) How would you describe a forest?
    a. What comes to mind when you think about forests?
    b. In your opinion what does a healthy forest mean?
    c. What's your favourite type of forest? Why?
5.) Also, what aspects of the forest are important to you both personally and professionally?
6.) Are there important services that Albertan forests offer to society? If so, describe them.
7.) Ok, over the last few questions you identified what you think a forest ecosystem entails. Is that fair to say? Are humans part of that ecosystem and if so in what ways? Should they?
    a. What responsibilities, if any, do people have in regards to nature?
8.) Scientists have suggested the forest is changing. Do you agree and what do you think are the causes?
9.) What are some best actions to ensure that a forest persists into the future? Or is any action needed at all to ensure this?
10.) Are there actions or activities committed by individuals or businesses within a forested area that you don't agree with?
    a. Are there harvesting techniques/technologies/or other management strategies that you would consider unsuitable to apply to forests? If so, explain.
    b. Are there situations where you would consider these alternative strategies as being valid?
11.) What concerns do you have about the forest?

    a.) What are the causes for these concerns?

    b.) Do you think those concerns are likely to change over time? In what way?

    c.) Should society make changes to address these concerns? How?

**I'd like to switch gears a little bit and talk to you about management and more specifically forest management.**

12.) To the best of your knowledge how are Alberta's forests managed?

a. Do you believe the province of Alberta is managing its forests well? How should Alberta ideally manage its forests? What management changes are necessary to maintain Alberta's forests?
b. Do you believe Alberta is properly preparing for the concerns you mentioned before?
c. Based off your own personal outdoor activities, what changes on an individual level would you like to see to help maintain Alberta's forests?

13.) In your opinion, what would mismanagement of Albertan forests look like?

**I would like to once again change topics a bit and talk about tree breeding and tree improvement.**

14.) First off, how knowledgeable are you about tree breeding efforts in Alberta? To the best of your knowledge can you describe the process?

a.) In your opinion are tree breeding efforts important for both present and future management of Alberta's forests? How? Why not?

My final set of questions for this interview involves a technology that you may or may not have heard of. It's ok if you haven't heard of it, but I'm interested in your initial thoughts or perceptions about what it is.

15.) So firstly, have you heard of genomic selection in any given context?

a.) Does anything come to mind when thinking about it? Any initial thoughts or impressions?

I'm going to now give you a brief explanation of what genomic selection is when applied in forestry. So, genomic selection is used in tree breeding to provide information and help make decisions. This information concerns determining which parental trees may produce offspring or progeny that have desirable traits. So, these desirable traits could be pest resistance or simply knowing the tree will grow faster. What this means is that by looking at the DNA of a tree, with conjunction with how it actually looks or responds to stress, we can build predictive models. These models help us determine which parents will produce offspring that can be planted with these desirable traits. Once these models are developed, a generation (~20 years) of progeny testing can be hopefully skipped or reduced and therefore genomic selection is faster than using current tree breeding methods because those methods rely on long periods of testing to see if and how desired traits develop. Genomic selection can hopefully remove that step and also offer greater production as well as accuracy to select said desired traits.

16.) With that being said, do you see genomic selection as a positive or negative tool to help manage Alberta's forests? In what ways? Barriers?

**That concludes my formal questions.** Is there anything you would like to add about genomic selection or forests in general? Concluding thoughts? As well, do you have any questions you would like to ask me? Is there anything you think I should have asked you, but I didn’t? Finally, as this study is doing a snowball sample I would like to establish interviews with people in Hinton and Whitecourt and I was wondering if you could provide me with contact information with anyone you may know working in that area? That is all of my questions, thank you for your time and participation in this study.

# Appendix B: Information Sheet & Consent Form

**INFORMATION LETTER and CONSENT FORM**

**Forest Values & Preferences: An Examination of Albertan Forestry Workers from Two Communities**


**Research Investigator:**
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*Background*

- You are part of this study as you represent a person who lives in a forest based community and your opinion is valuable.
- The results of this study will support my thesis and the information will be reported back to my sponsors who include: Genome Canada, Genome Alberta, Genome British Columbia, University of Calgary, University of Alberta, Alberta Innovates Bio Solutions, Blue Ridge Lumber INC, West Fraser Mills LTD, Alberta Ministry of Agriculture and Forestry, Weyerhaeuser, Forest Resource Improvement Association of Alberta and members of the project team.

*Purpose*

- This study hopes to find a range of people who have different opinions about the forest and how it is managed.
- As well, I want to understand what parts of the forest you think are important. Also, if you think these need protecting.
- Also, how you think society should interact with nature is of interest.
- This study also seeks to understand your first impressions about a technology called genomic selection and how you might feel about it after given a brief explanation.

*Study Procedures*

- This study will include interviews of 1-1.5 hours in length. The interview can take place in an area of your choosing. Some may prefer to participate over the phone rather than face to face. Interviews will be recorded unless you would prefer no recording, in which case I will take notes.
- The data will be used in my master's thesis, in reports and peer-reviewed journal articles and/or book chapters, and in oral presentations at professional conferences. The data will be retained indefinitely for potential inclusion in future studies. Future studies using secondary use of data will have to seek appropriate ethics approval.

*Benefits*

- You will be given $20 for joining this study.
- Your help in this study will also be of benefit to society, by helping forest decision making.
- As well, this study provides you the opportunity to learn a little bit about genomic technologies.

*Risk*

- There are potential risks with participating. Some of the questions and the nature of the interview process may cause some degree of stress. A few questions may create strong emotional responses. To control for these you are free to not answer any questions. If you so desire you can take a break from the interview at any time.

*Voluntary Participation*

- Partaking in the study is voluntary. You may refuse to answer certain questions, or end the interview at any time. You may also choose to contact me to withdraw part or all of your interview up to 30 days after transcription. In the event of withdrawal all data relating to you will be deleted or shredded.

*Confidentiality & Anonymity*

- Your name will not be identified in my thesis, any research papers, to sponsors, or in any presentations. Any information given will not have any impact on your present or future job prospects. However, unintended breaches in confidentiality may occur if the interview takes place in a public setting. Personal information will be linked to audio data. During transcription all identification will be anonymized. Only my supervisor and I will know your identity. Data will be kept confidential and held on a password-protected server. Both electronic and any physical copies will be held in a locked office. Only my supervisor and I will be able to access that data. This data will be retained indefinitely for potential future studies. Future studies using secondary use of data will have to seek appropriate ethics approval. If interested, you can email or phone me to request a copy of the findings.

*Further Information*

If you have any further questions regarding this study, please do not hesitate to contact me at ____.

The plan for this study has been reviewed by a Research Ethics Board at the University of Alberta. If you have questions about your rights or how research should be conducted, you can call (780) 492-2615. This office is independent of the researchers.

**Consent Statement**

I have read this form and the research study has been explained to me. I have been given the opportunity to ask questions and my questions have been answered. If I have additional questions, I have been told whom to contact. I agree to participate in the research study described above and will receive a copy of this consent form. I will receive a copy of this consent form after I sign it.

Participant's Name (printed) and Signature | Date

Name (printed) and Signature of Person Obtaining Consent | Date