Social Contexts of Environmental Practices:

How Sustainable Development Discourses and Trust Mediate the Use of Genomics in the Alberta Beef Industry

by

Anna Jane Louise Kessler

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

Master of Science

in

Rural Sociology

Department of Resource Economics and Environmental Sociology

University of Alberta

Abstract

In the face of environmental degradation resulting from beef production, genomics may add to the options available to producers seeking to reduce their environmental impacts. This research seeks to understand cow/calf producer experiences with the environment, the environmental impacts of their operation, and genomics by engaging with and building upon existing social theories. I draw upon sustainable development theory and literature on 'the good farmer' to call into question how cow/calf producers maintain self-perceptions as stewards of the land despite the environmental degradation attributed to the beef industry. Further, I explore theories of public understanding of science and the role of trust by examining cow/calf producers' and genomics researchers' perspectives on the role and impact of genomics in the beef industry. Results suggest that sustainable development narratives shape producers' experiences on the landscape and allow economic sustainability to be prioritised under the assumption that environmental sustainability will follow suit. Positive local environmental practices and impacts assist cow/calf producers in making sense of their simultaneous desire to care for the environment and participation in an industry that causes environmental harm. Overall, fragmented discourses of sustainability create space for producers to maintain a sense of stewardship while remaining disconnected from system wide environmental harms. With respect to public understandings of science and trust, producers seem to trust genomic science and researchers' knowledge and share similar views to researchers with respect to the role of genomics in the beef industry. However, producers are concerned with the social impacts the application of genomics may bring forth, particularly impacts to their own agency within the beef production system. In addition to considering multiple social

trust scenarios this research re-emphasizes the importance of interpersonal trust. Participants identify interpersonal trust in individuals with whom they are familiar as highly influential in shaping their environmental and technology adoption practices. The findings bring to the fore the importance of locality and familiarity in cow/calf producers' working relationships with the environment and others in the industry. Practical implications for the beef industry and contributions to the literature are also discussed throughout.

Preface

This thesis is an original work by Anna Jane Louise Kessler. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Understanding the Environmental Practices of Beef Producers”, PRO00041778, July 2013-July 2014.

Acknowledgements

I am fortunate to have been supported by so many people throughout this research. First, thank you to John Parkins, Emily Huddart Kennedy, and Ellen Goddard. I appreciate the time and energy you have spent developing and reviewing this work and challenging me throughout to continue improving. Thanks also to my family, friends, and partner for their continued encouragement and patience.

I would like to acknowledge the funding received from Genome Canada and the Social Sciences and Humanities Research Council of Canada. Additionally, I would like to acknowledge the travel assistance provided by the Profiling Alberta's Graduate Students Award through the Faculty of Graduate Studies and Research.

Very importantly, thank you to my many participants for sharing your time and stories and inspiring me by being endlessly enthusiastic and encouraging. I am so fortunate to have spoken with each of you.

Table of Contents

List of Figures

Chapter 1 - Introduction

Agriculture both relies on and impacts the health of the environment, especially features such as soil and water quality and quantity and the global climate. Most would agree that mitigating agriculture's potential environmental degradation is important. However, agreeing upon how to achieve this goal often results in conflict and contention. This thesis explores particular aspects of environmental management and agriculture. I focus on production, rather than consumption, practices related to beef, an animal protein with known negative environmental impacts. There are a number of reasons for this focus on production rather than consumption. In part, worldwide consumption is expected to increase as populations are increasingly financially able to access meat (McAlpine, Etter, Fearnside, Seabrook, & Laurence, 2009). Further, it is interesting to consider how production based solutions, such as the technology discussed herein, may contribute to more immediate impact reduction in addition to longer term strategies that address both production and consumption challenges. I focus on cow/calf producers' perceptions of using genomics as a vector for environmental improvements. Genomics, briefly, is the science that studies genes and relates gene characteristics to real world qualities (van den Heuvel, van Trijp, Gremmen, Renes, & van Woerkum, 2006). It is not my intention to advocate for or against this means of addressing the environmental impacts of livestock production and agriculture; rather, it is my hope this research will build upon existing social theory in a collective effort to better understand another dimension of agriculture and environmental management.

The environmental impacts of beef production are of concern globally and locally (Eshel, Shepon, Makov, & Milo, 2014). As the number of people worldwide gaining access to meat is growing, many anticipate increased consumption of beef over time (McAlpine *et al*., 2009) and have thus focused attention on production based impact reduction measures so as to meet a growing demand without further degrading the environment. One proposed means of alleviating the climate change contributions of beef production involves the use of genomics to selectively breed for cattle with increased feed efficiency (Bell, Wall, Russel, Simm, & Stott, 2011; de Haas *et al*., 2011). However, the use of biotechnologies such as genomics in agriculture and in the pursuit of

sustainability is socially complex in terms of both public and producer concerns, adoption practices, and impacts. In this context, this research has two inter-related purposes. Firstly, this research engages in ongoing dialogues in the literature pertaining to sustainability, agriculture, and the diffusion of innovation. To do so I focus on agricultural producers' experiences with the environment, perceptions of themselves and their roles relative to environmental impacts, and interactions with impact mitigation practices and technologies.

In addition, this study is part of the Genomics and its Ethical, Environmental, Economic, Legal, and Social (GE^3LS) Aspects component of the Canadian Cattle Genome Project, as required for all Genome Canada Research. The objective of GE^3LS components of Genome Canada is to "inform policies and practices that affect genomics research, as well as the use of genomic-based applications" so as to contribute to the "responsible application of genomic-based technologies" (Genome Canada, 2014). The Canadian Cattle Genome Project consists of three interconnected research streams: identifying social and economic costs and benefits of using genomics in breeding; developing low-cost, accurate genome-wide selection measures for breeders; and research and development means to facilitate the use of genome-wide selection to be used in Canadian cattle herd, particularly to enhance breeding for valuable difficult to measure traits (Canadian Cattle Genome Project, 2012). Therefore, in addition to engaging with relevant sociological theory, this study seeks to contribute to the practical goals of the Canadian Cattle Genome Project by enhancing understandings of socially based concerns and interests.

Overall, this research seeks to socially situate producers' environmental practices. Through social constructionism, discussed further below, scholars have come to understand that individuals' experiences with and interpretations of themselves and their social and physical environments are the basis on which individuals act (Greider & Little, 1988). This thesis focuses on experiences and perceptions of cow/calf producers so as to better understand their practices. These individuals are part of a social group that is considered integral to the viability of using genomics for environmental impact reduction measures. Cow/calf producers operate early in the beef supply chain and therefore make breeding decisions that impact the beef herds at subsequent phases of production. In

addition to these breeding choices, cow/calf producers continually interact with and make decisions about their environments. Their perspectives are therefore of interest for theorists seeking to understand environmental behaviours and to researchers seeking to have genomics accepted by cow/calf producers.

Research Objectives and Questions

Collectively, the research objectives and questions for this study constitute multifaceted contributions to our understanding of the place of genomics in reducing the environmental impacts of beef production and to environmental sociological theory related to these topics. One angle explores producers' experience with stewardship and environmental impacts on their land as well as globally, while the other approach focuses on the role trust plays in producers' perceptions of the use of genomics as a means of reducing GHG emissions. Chapters two and three of this thesis explore the following research objectives and associated questions, respectively.

The first objective is to understand how accounts of environmental degradation and pro-environmental producers co-exist within the minds of cow/calf producers and within the beef industry more generally. To do so I ask the following:

1) What narratives do producers draw upon to support their self-perceptions within these competing claims; and
2) How are these narratives used by producers to negotiate and reconcile their self-perception and their participation in a system that contributes to environmental degradation?

The second objective is to understand the means by which trust influences cow/calf producers' perceptions of the use of genomics in the beef industry. To meet this objective I ask:

1) In what ways do cow/calf producers' and genomics researchers' perceptions of the use and impact of genomics in the beef industry converge and diverge; and
2) How do these perceptions contend with current scholarship on the role trust plays in public understandings of science?

Methodology

Framework

This research is grounded in a social constructionist epistemology. As Daly (2007) notes, "social constructionism lies between the subjectivist and objectivist polar extremes. It accepts the presence of an external reality that is subjectively perceived and understood from the perspective of the observer" (p.32). Further, social constructionism takes into account the role of social interactions in the creation of meaning and propagation of practices based on perceptions of reality (Daly, 2007). Burr (2003) explains that social constructionism is critical of assuming unbiased understandings of the world and instead presents knowledge of the world as temporally and socio-culturally situated and maintained by social practices. In environmental sociology specifically, social constructionism is integral to moving past extremes of biophysical determinism and human exemptionalism to recognise that physical and social environments influence and form one another, in what Freudenberg, Frickel, and Gramling (1995) call conjoint constitution. Scholars have come to understand that personal experiences with social and physical environments are the basis on which individuals act (Greider & Little, 1988). Greider & Garkovich (1994) suggest individuals come to see their environments as symbolic landscapes, informed by the values and beliefs with which they define themselves. Subsequently, the way in which a person experiences their environment constitutes one of the foundations that predicates the actions they see as appropriate and what they feel responsible towards, thereby perpetuating some actions and excluding others (Burr, 2003; Greider & Garkovich, 1994). This epistemological framework guides my understanding of how individuals experience and come to know their physical and social worlds and has thus informed the formation of my research objectives as well as the position from which I approach my analysis. As such, this study explores how beef producers perceive the external environmental impacts of production in ways that are impacted by their experiences, frame of reference, relationships, shared meanings, feelings of trust, and practices.

This research employs a focused ethnography. Within the traditions of

anthropology (Knoblauch, 2005), ethnography is the study of an entire culture or cultural group with a focus on ideas, beliefs, behaviours, and patterns within the culture such that a description of how things are can be presented with a prescriptive account of how members of the culture act (Creswell, 2013; Marshall & Rossman; 2011). Often, the researcher attempts to adopt an emic, or insider, perspective (Creswell, 2013). This entails long-term emersion, or fieldwork, in a culture with which the researcher is relatively unfamiliar (Creswell, 2013; Knoblauch, 2005). In contrast, with focused ethnography a researcher focuses on small elements of one's own society, which is complimentary to sociological inquiry (Knoblauch, 2005). Focused ethnographies in this sense focus on particular actions, practices, interactions, situations, or phenomenon within a society. Large amounts of data are collected through various methods, often involving recording and transcribing of conversations, and intensive data analysis (Knoblauch, 2005). The segment of society of interest in this study consists of cow/calf producers who are facing complex environmental impacts and solutions.

Data Collection: Cow/Calf Producers

This research employed qualitative data collection and analysis. I conducted semi-structured interviews primarily with cow/calf producers, as well as with genomics researchers. For interviews with cow/calf producers, I developed the interview guide to cover three partially overlapping topics of discussion related to the study objectives. First, questions explored on farm practices, both positive and negative environmental impacts from the beef industry and from the participants' operations, and related decision making practices. This part of the interview was focused on understanding the environmental management practices participants' currently employed, their reasons for doing so, and the role of trust in influencing these practices. This section explored how producers see cow/calf production and the beef industry overall fitting into the natural environment and the values underlying these perspectives. Second, the interview focused on participants' views on use of genomics in the beef industry. Questions explored perceived risks and benefits of genomics to the beef industry and individuals' operations as well as participants' current practices and interest in genomics. I guided participants through a mapping exercise to further present their understandings of how genomics was likely to

become adopted within the industry and how they personally fit in. Throughout the mapping exercise, we explored participants' perceptions of the individuals and/or organisations involved with genomics, including their degree of trust in the abilities and intentions of these parties. Trust was the third focal area of the interview schedule. Questions pertaining to trust were incorporated into the conversations on the other two topics where applicable. Additional questions pertaining to trust were also included at the end of the interview guide to focus a reflective discussion. As guided by the theory, interpersonal and social trust, ability and intention related dimensions of trust, distrust and skepticism, and the development and function of trust were explored. This interview guide is included in Appendix A.

The selection criteria for this study required that the participant be involved in a cow/calf operation in a decision-making capacity and that this cow/calf operation be located in Alberta, Canada. Involvement with operations in other sectors or areas of the beef industry, in addition to cow/calf, was acceptable. This allowed for a broad range of perspectives to be represented while ensuring a focus on the decision making of cow/calf producers. As the target population was difficult to contact, referral sampling was used to access participants (Biernacki & Waldorf, 1981). One producer organisation agreed to distribute forms at their Annual General Meeting. These forms provided a brief explanation of the research project and a space for interested individuals to identify themselves. One form was returned and the individual participated in an interview. The primary means of recruiting participants involved the use of personal contacts in the industry, followed by referrals from those contacts and from resulting interviews. Participants, if willing, were asked to provide the name and contact information for individuals meeting the selection criteria. The researcher suggested to participants that they might want to refer a contact with a different point of view from their own.

Individual interviews were conducted with participants throughout the province of Alberta. Twenty-two individuals were contacted with interview requests and seventeen of these individuals completed interviews. Of the individuals who did not participate, one confirmed that they did not meet the selection criteria, two did not reply to either the initial phone call or the follow up, and two had ongoing scheduling conflicts. Of the completed interviews, thirteen were conducted in person and four were conducted by

phone. Of the in person interviews, twelve took place at the participants' homes and/or cow/calf operation and one took place at the University of Alberta. Two in person interviews involved both the intended participant and their spouse, as both individuals were involved in partnership in the operation. Two other in person interviews involved occasional comments from the participant's spouse. However, these interviews are still regarded as one interview. The interview schedule was designed to facilitate an hour to an hour and a half long conversation. In practice, interviews lasted between three quarters of an hour and two and a half hours. The majority of interviews lasted approximately an hour and a half. All participants agreed to have the interview recorded. Seventeen interviews sufficed to attain saturation, as no thematically new data was collected within the last few interviews. The interview guide facilitated this as it was designed and focused to foster saturation.

Data Collection: Genomics Researchers

A separate interview guide was prepared for use with genomics researchers. This guide explored researchers' roles within beef cattle genomics, the role and adoption of genomics in the beef industry, the use of genomics to alter the beef industry's environmental impact, feed efficiency and related environmental impacts, and the role of producer trust in adoption of genomics in the beef industry. These interviews were designed to provide context and comparison for producer interviews. Some information as to the state of beef cattle genomics research can be attained through a review of the literature. However, in person discussions with researchers elicited detailed accounts of the progress of genomics research and anticipated reception in the beef industry. Perceptions of these researchers regarding means of adoption and the role of trust could be compared to responses from cow/calf producers on these matters in order to bring forth similarities and discrepancies. This interview guide is included in Appendix B.

As I sought to access a specific realm of expertise within genomics researchers, purposive sampling (Tongco, 2007), with the assistance of a key informant, was used to select researcher participants. An internet search of researchers at the University of Alberta involved with beef cattle genomics was completed using combinations of the follow search words: beef, cattle, bovine, genomics, genetics, research, Alberta,

University of Alberta, feed efficiency. Additionally, the websites of beef cattle genomics research groups, The Canadian Cattle Genome Project (www.canadacow.ca) and Livestock Gentec (http://www.livestockgentec.com), were used to identify participants. Further, a key informant assisted in narrowing the list to a selection of individuals who were knowledgeable in the area of beef cattle genomics, primarily, and feed efficiency, to varying degrees, and who would provide varied perspectives. All seven researchers identified as possible candidates participated in this study.

Each of the seven individuals contacted and interviewed were associated with Livestock Gentec to varying degrees. In addition to associations with Livestock Gentec some participants were employees of the federal government, professors at the University of Alberta, and/or industry associates. Interviews took place in participants' offices and lasted between three-quarters of an hour and an hour and a half. All but one participant agreed to have the interview recorded

Analysis

Interviews were recorded and transcribed using ExpressScribe software. Recordings were transcribed verbatim and long pauses, laughter, interruptions, and occasionally intonation were also identified. While transcripts were not altered to correct grammatical errors, direct quotes were edited where necessary to improve readability. Theoretical thematic analysis of the set of cow/calf producer interviews and the set of researcher interviews was conducted. Braun and Clarke (2006) explain theoretical thematic analysis is, in contrast to inductive or grounded theory based analysis, "driven by the researcher's theoretical or analytical interest" (p.84). It is used to "find repeated patterns of meaning" (Braun & Clarke, 2006, p.86) within qualitative data. The research questions of this study and associated objectives were used to focus the thematic analysis to specific parts of the interview data. This approach to thematic analysis is in keeping with the constructionist epistemological foundation of this project and as such "seeks to theorize the sociocultural contexts, and structural conditions, that enable the individual accounts that are provided" (Braun & Clarke, 2006, p.85). NVivo 10 for Macs software was used for coding data and related analysis. To maintain a focus on the respective research objectives and questions, coding was completed separately for each paper, albeit with some overlap. Codes were

defined, reviewed, and refined with re-coding of texts completed as necessary. Codes were then gathered into themes, guided by the theoretical framework and research objectives. Throughout, memos were used to explore consistencies and differences between the dataset themes and the existing literature.

Limitations

The most significant limitations of this research are associated with challenges in participant recruitment. While many producer organisations have extensive lists of cow/calf producer members, this information proved inaccessible to researchers. As such, two participant recruitment methods were employed. Primarily, referral sampling was used. This sampling method is recognised as a useful method of research recruitment with hard to reach populations (Biernacki & Waldorf, 1981). Starting from industry contacts of one committee member and myself, participants were contacted through subsequent referrals. Additional participant recruitment was attempted through the distribution of flyers at the 2014 Alberta Beef Producers' Annual General Meeting. Onus was on interested individuals to contact the researchers and only one participant resulted from these efforts. Further, given varying willingness or ability to refer further participants, the producer participant referral chains are not all equal. Researcher participants were contacted through a key informant who narrowed the available list of genomics researchers to those interested particularly in beef cattle genomics. All researcher participants were associated with the University of Alberta and collaborated with each other to varying extents. Therefore, it is possible in this study that alternative perspectives were not heard. However, the perspectives heard do speak directly to the Albertan context of this research. Overall, this research does not claim to speak to the views of a representative sample of beef producers or beef cattle genomics researchers. However, as thematic saturation was attained, I am comfortable with the suitability of this data to engage with existing literature and offer food for thought to the beef industry.

Additionally, as this study focuses on the Alberta beef industry I cannot attest to the applicability of my conclusions for other contexts. Different social, cultural, and material conditions in other beef producing regions may result in producers having

different experiences with the environment, with genomics, and with trust. The theoretical perspectives developed herein present possible understandings for future research to explore rather than wide reaching explanations.

The Researcher

The participants in this study were quick to inquire as to the reasons for my interest. As such, my positionality was never far from mind. Firstly, I am a "city girl" with no farm background, qualities that seemed fairly obvious to most participants. Secondly, I have been vegetarian for the entirety of my adult life, although this was not something I spoke openly about with participants. Why then, do I care about this topic? In truth, my answer is evolving. Agriculture is a significant part of the social and physical landscapes of Alberta; thus, as an Albertan who cares about both livelihoods and the environment my interest in mitigating environmental impacts from agriculture feels very natural. Additionally, my perceptions of the environmental impacts of meat production contribute to my decision to not consume it; however, I recognise my decision contributes marginally to reducing these impacts and I am interested in a multitude of ways to protect the environment. My work background in environmental assessment further developed my interest in resource development and available options for impact mitigation and environmental protection on the production side.

Since I do not eat beef, at times I inadvertently forgot that I was engaging with the production of *food* in particular, not just any resource development. I believe this was both an asset and a challenge. Beginning from a resource development and environmental impact perspective, I initially explored literature more broadly pertaining to sustainability, technology, and agriculture; I believe the scope of theory is broader than I might have thought to consider had I maintained a focus on the production of food specifically throughout. However, at times it was challenging to remain mindful to become familiar with and engage with current discussions around sustainable food production and consumption.

Throughout my research I was touched by the generosity of all participants who shared their time and stories and welcomed me into their homes and offices. As such, I

contended with a desire to both honour all stories and critically engage with these accounts. I must admit, I was pleasantly surprised and encouraged by the passion for environmental protection exhibited by the producers I met. As such, I also had to reconcile a newfound appreciation for cow/calf producers' self-perceived stewardship with the undeniable environmental impacts resulting from beef production. Overall, participants' accounts added dimensions the interactions between agriculture and the environment that I had previously not considered and thus challenged my own world-views in critical and productive ways.

Organisation of Thesis

This thesis includes two, separate papers addressing cow/calf producers' perceptions of the environment and genomics, drawing from separate but related bodies of theory. Chapter 2 focuses on how competing claims of environmental stewardship and environmental degradation in the beef industry, and how these competing claims are reconciled by cow/calf producers to maintain a sense of legitimacy. By exploring cow/calf producers' perspectives on the use of genomics for emissions reductions purposes, this paper identifies how sustainable development narratives, informed by personal, local experiences, are used to substantiate claims of stewardship while simultaneously creating space to prioritise economic sustainability. Chapter 3 focuses more directly on how cow/calf producers perceive the role and impact of genomics in the beef industry and the place of trust relative to these perceptions. Genomics researchers' perspectives are also incorporated into this paper; points of convergence and divergence in researcher and producer perspectives contribute to understanding how trust influences producers perceptions both of the science and the impacts of its adoption. In the concluding Chapter 4, I summarize key theoretical and practical implications, discusses the theme of familiarity – between producers and environmental impacts and interpersonal relationships of trust - woven throughout the substantive chapters, and recommend future directions for research.

References

Bell, M., Wall, E., Russell, G., Simm, G., & Stott, A.W. (2011). The effect of improving cow productivity, fertility, and longevity on the global warming potential of dairy systems. *Journal of Dairy Science*, *94*, 3662-3678.

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*, *10*(2), 141-163.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Burr, V. (2003). *Social Constructionism*. Psychology Press.

Canadian Cattle Genome Project. (2012). Science. Retrieved from http://www.canadacow.ca/project/science

Creswell, J. (2013). Five qualitative approaches to inquiry. *Qualitative Inquiry & Research Design: Choosing Among Five Approaches.* Los Angeles: SAGE.

Daly, K.J. (2007). Epistemological considerations in qualitative research. *Qualitative Methods for Family Studies & Human Development*. Ed. K.Daly. Thousand Oaks: SAGE. pp.19-27.

de Haas, Y., Windig, J.J., Calus, P.L., Dijkstra, J., de Haas, M., Bannink, A., and Veerkamp, R.F. (2011). Genetic parameters for predicting methane production and potential for reducing enteric emissions through genomic selection. *Journal of Dairy Science, 94*, 6122-6134.

Eshel, G., Shepon, A., Makov, T., & Milo, R. (2014). Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *Proceedings of the National Academy of Sciences*, *111*(33), 11996-12001.

Freudenburg, W. R., Frickel, S., & Gramling, R. (1995). Beyond the nature/society divide: Learning to think about a mountain. *Sociological Forum 10*(3), 361-392.

Genome Canada. (2014). Welcome to Genome Canada's GE3LS Page. Retrieved from http://www.genomecanada.ca/en/ge3ls/

Greider, T., & Garkovich, L. (1994). Landscapes: The social construction of nature and the environment. *Rural Sociology*, *59*(1), 1-24.

Greider, T., & Little, R. L. (1988). Social action and social impacts: Subjective interpretation of environmental change. *Society & Natural Resources*, *1*(1), 45-55.

Knoblauch, H. (2005). Focused ethnography. *Forum: Qualitative Social Research*, *6*(3).

Marshall, C. & Rossman, G.B. (2011). Qualitative research genres. In C. Marshall & G.B. Rossman (Eds.) *Designing Qualitative Research*, Los Angeles: SAGE.

McAlpine, C. A., Etter, A., Fearnside, P. M., Seabrook, L., & Laurance, W. F. (2009). Increasing world consumption of beef as a driver of regional and global change: A call for policy action based on evidence from Queensland (Australia), Colombia and Brazil. *Global Environmental Change*, *19*(1), 21-33.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research & Applications*, *5*, 147-158.

van den Heuvel, T., van Trijp, H., Gremmen, B., Jan Renes, R., & van Woerkum, C. (2006). Why preferences change: Beliefs become more salient through provided (genomics) information. *Appetite*, *47*(3), 343-351.

Chapter 2 - Locality, Materiality, and Sustainable Development Discourses: Environmental Impacts and Stewardship in the Beef Industry

Introduction

Conflicting accounts of the beef industry's impact on nature are prevalent in lay, industry, and academic discussions. On one hand, the industry emits up to 18% of global greenhouse gas (GHG) emissions (Garnett, 2009). Landscape level impacts include soil degradation and erosion, loss of wildlife and plant biodiversity and habitat, and reduced water quality all of which may be widespread across a region. This account of worrisome environmental degradation takes into consideration the whole system of beef production situated within industrial agriculture. On the other hand, individual producers within this industry express deep appreciation and concern for the natural environment, state they rely on ecosystem health for the continuation of their operations, and claim to undertake a multitude of positive environmental management practices (see for example Ellis, 2014; Silvasti, 2003). In contrast to accounts of degradation that consider the broader production system, accounts of stewardship are presented at the level of individual operations.

Given, these dueling narratives about the beef industry, the objective of this study is to understand the space in which these conflicting, yet legitimate, claims are simultaneously held, by exploring cow/calf producers' perspectives on the links between beef industry practices and broader environmental impacts. To do so I ask the following: (1) What narratives do producers draw upon to support their self-perceptions within these competing claims? and (2) How are these narratives used by producers to negotiate and reconcile their self-perception and their participation in a system that contributes to environmental degradation?

Understanding the space in which conflicting claims of environmental impacts exist and producers' perspectives therein is important for several reasons. Working towards environmental improvements requires recognition that the current beef production system needs to change, most likely in a number of ways involving individual

producers. Therefore, the extent to which farmers are reflective about this need for change and are thus willing to adopt or modify environmental management practices, such as the use of genomics to this end, is a key step toward effecting change. In exploring this tension, this study shows that producers defend their positions as stewards by employing sustainable development narratives. The embodiment of environmental experiences and knowledge privileges a focus on local, lived experiences with tangible impacts that contribute to fragmented discourses of sustainability amongst cow/calf producers. Producers draw from their material experiences with the environment to distinguish themselves from relatively more environmentally harmful areas of the beef industry or other industries and to valorize the presence of cow/calf production on the landscape.

This paper begins with a literature review exploring the conflicting accounts of the environmental impacts of agriculture and livestock production and producers' accounts of pro-environmental beliefs and behaviour. I then outline key debates in the sustainable development literature that address the tension between environmental protection and economic growth. Building upon this, I discuss the literature pertaining to sustainable development and technology with a focus on genomics. The incorporation of sustainable development into individual lived experiences and embodied knowledge is then discussed. In the following section, I focus on cow/calf producers' experiences and narratives of sustainable development. The use of genomics as a vector for environmental improvements is used throughout as an example of an emerging environmental management option. Exploring producers' perceptions of this technology elicits narratives pertaining to environmental management and climate change. These narratives are important considering the GHG emissions attributed to the beef industry.

Literature Review

The Competing Claims

That agriculture has an impact on the environment is undeniable. As succinctly put by Paarlberg (2010), "from a pure ecological perspective, all forms of agriculture damage the natural environment" (p.110) through clearing of land, modification of

waterways, and the domestication and modification of plants and animals. The extent to which this impact occurs and is negative, the extent to which we ought to be concerned, and the options available for reducing environmental harms while feeding a global population have been the subjects of countless studies. Many recent estimates, however, present a rather grim picture, especially with respect to climate change. The landscape level impacts of agriculture are complex and difficult to measure, in part due to the non-point-source nature of individual operations' contributions to cumulative impacts (McGuire, Morton, & Cast, 2014). The global impacts in terms of emissions from agriculture have been estimated. The production of food for consumption in the global North contributes from 15% to 28% of overall national GHG emissions (Heller, 2013). Life cycle analysis focused on livestock suggest that livestock may be responsible for between 18% and 51% of anthropogenic GHG emissions globally and that a "25 per cent reduction in livestock products worldwide between 2009 and 2017 could result in a 12.5 per cent reduction in global atmospheric greenhouse gas emissions" (De Schutter, 2014, p.6). Thus, it is clear GHG emissions are one of the most significant environmental concerns associated with beef production (Bell *et al.*, 2011; de Haas *et al.*, 2011; Nguyen, Hermansen, & Mogensen, 2010; Tan, Tan, & Khoo, 2012).

On farm emissions are important targets for GHG reductions efforts. In beef production, 80% of emissions result from the cow-calf phase and 20% of emissions occur during the feedlot phase (Beauchemin, Janze, Little, McAllister, & McGinn, 2011). Many of these emissions are the result of feed production and digestion (Figure 1).

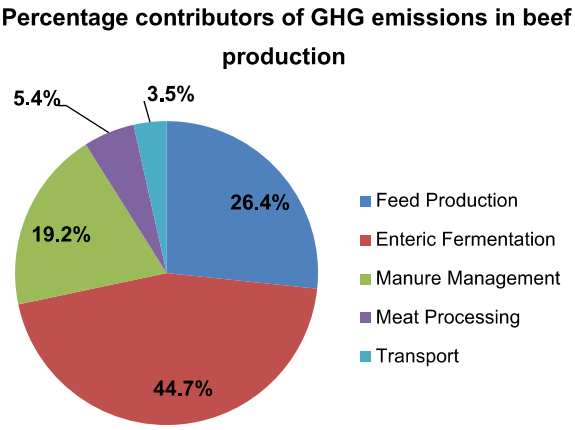

Fig. 9. Percentage GHG contributions in the life cycle stages of beef production (averaged from total CF).

Figure 1: Percentage contributors of GHG emissions in beef production (from Tan *et al.*, 2012, p.82)

In his report to the United Nations on the right to food, De Schutter (2014) prescribes reductions in demand for beef products in regions where nutritional requirements have been satisfied as part of sustainable consumption. Additionally, the report recommends reducing methane emissions by reducing enteric fermentation by livestock. The report recommends changes to livestock feed intake. However, increases in animals' feed efficiency, which may be achieved more quickly and accurately with the use of genomics, could also contribute to methane emission reductions (Bell *et al.*, 2011; de Haas *et al.*, 2011). This use of genomics, as a way to address environmental concerns in the beef industry, is a point of focus in this paper.

Accounts of environmental degradation take into account the beef production system as a whole. At the time of this writing, in Alberta, Canada, there are approximately 4,905,900 beef cattle (Statistics Canada, 2014), 39,000 commercial cow/calf operations, 347 feedlots of over 1000 head, and an output of 68,000 head per week from packers (Alberta Cattle Feeders Association, 2014). The scale and distribution of this industry illustrates the potential for significant cumulative environmental impacts, but also the scale at which environmental improvements could be made given the implementation of adequate impact mitigation measures. The decisions made by individual operators, dispersed across large areas, influence the degree to which negative

environmental impacts occur. It is clear that cow/calf producers make decisions affecting local environmental impacts. They also make breeding decisions that impact the genetic makeup of the cattle moving through the beef supply chain. Cow/calf producers' adoption rates therefore impact the viability of the use of genomics for emissions reductions. Given the influence of individual producers' decisions on local, cumulative, and global environmental impacts, it is necessary to consider their perspective relative to the environment and the beef production system overall. It is here that the disconnect between reported environmental impacts and reported environmental behaviours becomes apparent.

In contrast to concerning accounts of environmental degradation, ideas of "the good farmer" are present within industry narratives and many academic studies (Burton, Kuczera, & Schwarz, 2008; Ellis, 2013). While conventional agriculture is increasingly being identified as a source of environmental harms, many involved in the industry cite a different experience (Ellis, 2013; Silvasti, 2003). Sociological research with farmers and ranchers has identified deeply held beliefs and accounts of agriculture being in harmony with nature (Silvasti, 2003). Frequently, farmers identify a tended landscape as valued above a conserved or preserved landscape. In these farmers' perspectives "[n]ature, its rhythm and power, is respected. In order to guarantee the continuity of the family farm, the protection of land and nature is indispensable" (Silvasti, 2003, p.147). Ellis' work with ranchers in the western United States details this prominent narrative. Stewardship is defined as "the responsible use (including conservation) of natural resources in a way that takes full and balanced account of the interests of society, future generations, and other species, as well as of private needs, and accepts significant answerability to society" (Worrell & Appleby, 2000 as cited in Ellis, 2013, p. 436). Husbandry introduces protection and care of livestock to stewardship. Stewardship and husbandry are dominant values in ranchers' self-perceptions (Ellis, 2013). Burton (2004) and Burton *et al.* (2008) also suggests that just as stewardship is integral to producers' identities, farmers celebrate productivism – a focus on maximizing production through intensification - because it represents their ability to feed the world. Producers' values of stewardship and productivism together construct the use of the land to its full potential as normative (Burton, 2004; Burton *et al.*, 2008). Thus, environmental management practices that

enable continued and increased production are most likely to be undertaken (Burton *et al.*, 2008). In their study on farmers' identities McGuire *et al.* (2013) elucidate how positive feedback loops of experiences with production and conservation reinforce farmers' self perceptions as good farmers. Environmental and social experiences and performance provide farmers with an embodied sense of self relative to nature and food production (McGuire *et al.*, 2013). In cases where empirical measurements suggested non-adherence to stewardship ideals, two outcomes were possible: producers either adjusted their definition of a good farmer or adjusted their behaviours to match their current conceptualisation of a good farmer. The chosen outcome depended on a producer's balance of productivist and conservationist values (McGuire *et al.*, 2013). Some literature argues that values of stewardship, husbandry, and productivism mask power relations between humans and nature and create barriers to improving environmental management practices on individual operations (Burton, 2004; Ellis, 2014; Silvasti, 2003). McGuire *et al.* (2013) identify the need to "reduce the tension and rebalance the relationship between farm-level productivity and collective-level environmental sustainability (Morton *et al.* in press)" (p.66). Overall, tensions between productive or economic sustainability and environmental sustainability dominate this conversation.

Collectively, farmers' self-perceptions as stewards are part of ongoing socialization processes that establish similarities in individual' interpretations of their experiences and thereby establish similarities in individuals' behaviour. The way farmers experience the environment predicates the actions they see as appropriate and what they feel responsible towards, thereby perpetuating some actions and excluding others (Greider & Garkovich, 1993). Undertones of sustainable development discourses are woven throughout accounts of producers' stewardship and productivism described above. Luke (2005) describes the acculturating nature of sustainable development discourses and suggests that "once the effects of sustainability begin to shape the fields of action and decision, they are integrated into the shared habitus" (p.230). The impact of sustainable development discourses on agricultural producers' lived experiences, or shared habitus, is evident in the literature and worthy of further exploration. Therefore, in this research,

sustainable development, biotechnology in sustainable development, and sustainable development in agriculture are important considerations.

Critiques of Sustainable Development and the Role of Biotechnology in Agriculture

The concept of sustainable development and its application have been assessed and critiqued numerous times since the Brundtland Commission defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). However, while mainstream politics tout sustainable development as normative, a clear definition has yet to emerge. This ambiguity is celebrated by some practitioners or policy makers as inclusive and reconciliatory of otherwise conflicting interests (Lang & Barling, 2013; Lele, 1991; Robinson 1994; Seghezzo, 2009). In contrast, a vague conceptualisation is also problematic given the popular use of sustainable development as a policy objective. Often, sustainable development is considered a "'metafix' that will unite everybody from the profit-minded industrialist and risk-minimizing subsistence farmer to the equity-seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth-maximizing policy maker, the goal-oriented bureaucrat, and therefore, the vote-counting politician" (Lele, 1991, p.613). The ability of sustainable development to be socially, economically, and environmentally satisfying has fallen short of this proposed 'metafix'. A related prominent critique explores how sustainable development discourses relegate environmental considerations as subservient to economic interests. With the introduction of sustainable development into popular vernacular, debate shifted from how environment and development are in conflict to how we can achieve sustainable development (Lele, 1991). Underlying this shift is the assumption that "ecological sustainability and traditional developmental objectives (such as the satisfaction of basic needs) could be mutually reinforcing" (Lele, 1991, p.610). However, frequently, economic growth, specific social orders, and human rather than ecosystem needs are what individuals, organisations, and governing bodies focus on sustaining (Banerjee, 2003; Robinson, 2004; Seghezzo, 2009; Redclift, 2005). The Brundtland Commission encourages a focus on human inter-generational needs and promises improvements to

environmental and social sustainability through economic growth (Imran, 2014). In this line, the assumption that economic growth will lead to environmental sustainability permits a lack of attention to environmental protection directly. The perception that environmental regulation will slow or prevent economic growth has been promoted by industries the world over (Freudenberg *et al.*, 2005). Coupled with sustainable development's mandate to promote economic growth this fallacy has contributed to inadequate environmental protection at a legislative level (Freudenberg *et al.*, 2005; Imran, 2014). O'Riordan and Voisey (1997) argue that while there are multiple interpretations of sustainable development "reliable and continuous wealth creation is by far the most powerful at present" (p.6). In short, development has become equated with economic growth and sustainable development with sustained economic growth (Robinson, 2004; Imran, 2014).

The role of technology is at the heart of many sustainable development debates. Specifically, in agriculture, biotechnology is often in the forefront of these conversations and positions are polarized. Supporters of the use of biotechnology tout its contributions to sustainable development and often espouse optimistic values of ecological modernisation. For example, the use of transgenic crops may reduce pesticide and herbicide use resulting in positive human health impacts and reduced environmental harms such as eutrophication and GHG emissions (Park, McFarlane, Phipps, & Ceddia, 2010). Many suggest that food requirements globally will double by 2050 and that biotechnology is the solution to meeting this demand since there is little agricultural land to expand on (Park *et al.*, 2010). The demand for meat, in particular, is expected to increase with changes in purchasing power (Horsling & Marsden, 2011) and biotechnology may allow for increased production without increased inputs and emissions (Bell *et al.,* 2011; de Haas *et al.*, 2011). In this camp, productivist, agri-industrial model is promoted as necessary, with biotechnology as the tool to enable economic growth and agricultural production as the solution to issues of food security and environmental harms (Horsling & Marsden, 2011; Park *et al.*, 2010). The assumptions of sustainable development are evident in this perspective; biotechnology is lauded as the means of achieving a win-win situation wherein economic growth remains unquestioned and environmental sustainability is achieved.

However, many researchers are critical of the proposed win-win biotechnological solutions. Critiques often take into account the successes and failures of the green revolution and call for a 'real green revolution' - an agro-ecological rather than agro-industrial food system (Horsling & Marsden, 2011; Shiva, 2000). Shiva (2000) calls attention to the ways in which biotechnology reduces food security due to corporate control over seeds and production. Income inequality, malnutrition, loss of biodiversity, and ground water contamination are some of the negative social and environmental impacts resulting from the green revolution and associated use of biotechnology (Parlberg, 2010; Shiva, 2000). Opponents of biotechnological solutions to the social and environmental impacts agriculture reject sustainable development that is based on ecological modernisation and which "seeks to find ways to work from within the prevailing capitalist and carbon-based economy to bring about both ecological balance and economic development" (Horsling & Marsden, 2011, p.445). Instead, this camp proposes an agro-ecological food system that promotes small scale farming, community collaboration, polycultures, biological rather than chemical pest control and soil nutrient management, and water harvesting rather than irrigation as the environmentally and socially sustainable solution (Parlberg, 2010). A moderate approach to this debate suggests, "there is no technological panacea for the global challenge of sustainable and secure food production … new crop varieties and appropriate agro-ecological practices are both needed" (UK Royal Society, 2009 as cited in Park *et al.*, 2010). Current perspectives on the use of biotechnology in agriculture reflect debates on discourses of sustainable development and the potential for environmental health to be neglected in favour of economic sustainability.

The place of biotechnology in sustainable agriculture is debated. However, sustainable agriculture is a relatively unquestioned priority for individuals, organisations, and governments globally. Agriculture, as the foundation of society, is one of the most significant and complex human-environment interactions (Lele, 1991). Lele (1991) presents this issue: "the ability of a pattern of agriculture to simultaneously provide fair returns to the farmer and laborer, and to satisfy the needs of the nonagricultural population in an ecologically sound manner, depends not only on ecological interactions but also on complex social conditions" (p.617). Indeed, the definition of sustainable

agriculture is no more agreed upon than that of sustainable development (Thompson, 2007). At times agro-industrial and agro-ecological models are sharply juxtaposed, while at other times a spectrum is drawn. Regardless, the importance of farmers' lived experiences and socio-environmental constructions of sustainable agriculture, the environment, and themselves are stressed throughout recent literature (Burton *et al.*, 2008; Carolan, 2006; Ellis, 2013; Freudenberg *et al.,* 1995; Silvasti, 2003). These authors suggest that research attempting to understand the nuances of producers' environmental management decisions must move past attitudinal and cognitive measurements. It is necessary to understand decisions in socio-cultural (Burton *et al.*, 2008), socio-environmental contexts (Freudenberg *et al.*, 1995), and appreciate the influence of embodied experiences and knowledge (Carolan, 2008). It is argued that socially, culturally, and environmentally situated values are integral to farmers' constructions of sustainable development and subsequent actions with respect to the environment.

These debates surrounding sustainable development, sustainable agriculture, and biotechnology apply to the use of genomics in the beef industry. This chapter engages these ideas by considering the use of genomics as a means of reducing the environmental impacts of the beef industry. As background, the use of genomics does not involve genetic modification. Rather, DNA markers on the genome are used to select specific animals for breeding. Traits such as increased feed efficiency, which allow for the same amount of beef to be produced with fewer inputs and less waste, are currently of interest for environmental and economic purposes. This research explores participants' views on this use of genomics and seeks to socially and materially situate these views.

Divergent Embodiment and Fragmented Discourses of Sustainability

One proposed means of gaining insight into producers' behaviour is to consider their knowledge of, perspectives on, and experiences with the environment as more than cognitive and discursive. This involves focusing on the materiality of producer' interactions with their land (Carolan, 2008). Materiality in this sense emphasizes a role for producers' physical, corporeal experiences working with their land and animals, in addition to acknowledging the social constructions of meaning (Carolan, 2008). This could include, for example, the physical act of moving cattle from one area to another to

graze. Considering materiality is also a proposed means of reconceptualising and adding depth to interpretations of sustainable development. Redclift (2005) suggests we ought to "examine the way in which new materialities influence the cultural constructions we place on the environment" (p.225). Moving forward, sustainable development linked to material realities given changes in science, technology, and consciousness may gain more of a focus on environmental sustainability (Redclift, 2005). In support of incorporating consideration of the material into our conceptualisations of sustainable development, Urry (2000) explains "the human and physical worlds are elaborately intertwined and cannot be analysed separately from each other, as society and as nature, or humans and objects" (p.194). Further, Urry (2000) suggests that "societies are necessarily hybrids" (p.195) because all social experiences involve humans and non-human entities. Looking at hybridity in rural settings, recent research on farming and non-farming rural residents' experiences with the countryside found that both of these two groups come to think of and understand their surroundings corporeally, based on proximate, physical experiences (Carolan, 2008). Farmers experienced different physical ways of knowing the environment than did non-farming rural residents. For example, famers cited knowing their land through their tractor and non-farmers cited knowing the land through the view from their vehicle or bicycle. Also, farmers included specific agriculture related scents and sights into their descriptions of their landscape, while non-farmers were more vague and romantic in their descriptions. Carolan (2008) calls this "divergent embodiment" and suggests that particular physical, material experiences may contribute to farmers' perspectives on appropriate land use and practices. In their work, Carolan (2008) noted different material experiences and subsequently different attitudes resulted in conflicting views of farming and non-farming rural residents.

In this line, if physical experiences of knowing the environment and nature influence how farmers perceive themselves within it, it follows that a lack of physical experience with an environment or impact may result in a different or lesser understanding. The tangibility and immediacy of costs and benefits influence farmers' propensity to adopt a practice or technology targeted towards a specific environmental impact (Carolan, 2006; Urry, 2000). Urry (2000) emphasizes the importance of locality and notes that individuals only take in information that is immediately present. Thus,

drawing upon Marx, "each capitalist operates under conditions that are far from equilibrium; they can only respond to 'local' sources of information since relevant information carries across only a limited temporal and spatial range" (Urry, 2000, p.197). Carolan (2006) calls this "epistemic distance" and identifies related barriers to sustainable practices, in an agricultural setting in particular. Where farmers can come to know environmental impacts physically they are likely more prone to act; immediate, tangible benefits may be pursued most readily (Carolan, 2006). However, not all of the effects of environmental management practices or practices that emphasize environmental health may be experienced on farmers' own land. For example, the use of genomics in selectively breeding for increased feed efficiency has, to date, been targeted as an emissions reduction strategy. Adoption practices may be influenced by the fact that cow/calf producers do not materially experience the environmental impacts of emissions reductions. Overall, this body of theory suggests embodied, material knowledge of the environment affects farmers' perceived landscapes and thus both predicates the actions they see as appropriate (Greider & Garkovich, 1994) and shapes their conceptualisations of sustainable development. What Carolan (2008) named divergent embodiments may thereby contribute to fragmented discourses of sustainability when some environmental impacts are materially experienced and others are not.

These theoretical perspectives speak to the objectives and questions of this research. Critiques of sustainable development and debates surrounding the use of biotechnologies, such as genomics, for sustainable development ends provide perspective on how economic sustainability becomes prioritised with the optimistic, and often false, assumption that environmental sustainability will ensue as a byproduct. The idea that sustainable development discourses may pervade experiences with the environment and in turn are influenced by the local, material environment directs us to explore narratives in this vein. Competing claims of sustainability and environment harms in the beef industry are applied at different scales and may thus be elucidated by considering divergent embodiments. This study builds on the existing literature looking at the disconnect between environmental harms and "pro-environmental" producer values by considering the material, lived experiences and knowledges that producers hold and use to explain their thoughts and actions.

Methods

A focused ethnography was used in this research. When conducting a focused ethnography the researcher focuses on small elements of one's own society, which is complementary to sociological, as opposed to anthropological, inquiry (Knoblauch, 2005). Focused ethnographies in this sense focus on particular actions, practices, interactions, situations, or phenomena within a sub population of a society. In keeping with the methods of focused ethnographies, qualitative semi-structured interviews were used as the primary means of data collection. A total of 17 interviews were conducted with all but 4 interviews being completed in person. The selection criteria for participation required only that producers be in a decision-making capacity in a cow/calf operation located in Alberta, Canada. Referral sampling, starting from industry contacts of the researchers, was used to access producers as the target population proved difficult to access by more conventional sampling techniques (Biernacki & Waldorf, 1981). Interviews were conducted until thematic saturation was reached. In the end, participants were involved with cow/calf operations ranging in size from 25 mother cows to 1200 mother cows, with the majority having between 200 and 500. All participants owned at least a portion of the land on which they operated and a portion of the cattle they grazed. In addition to cow/calf operations, some participants operated feedlots (2 participants), seedstock operations (2 participants), mixed cattle and grain farms (4 participants), and custom grazing services (2 participants). Pseudonyms were assigned to all participants and are used in the presentation of findings.

Interview questions focused on how participants saw their operations and the beef industry overall fitting in with the natural environment, the physical features of the land on which they operate, their interactions with individuals and industry organisations relating to environmental management, and important considerations when making adoption related decisions. As the use of genomics to selectively breed for increased feed efficiency was used as an example of an emerging environmental management practice, specific questions were asked on this topic. These covered participants' views on role,

risks, and benefits of genomics overall, the environmental implications of this use of genomics, and their likeliness of using genomics. The full interview guide is presented in Appendix A.

Interviews were recorded, transcribed, and analysed with theoretical thematic analysis. ExpressScribe and NVivo 10 for Macs software were used for transcribing and analysis respectively. Theoretical thematic analysis is used to "find repeated patterns of meaning" (Braun & Clarke, 2006, p.86) within qualitative data. The research questions of this study and associated objectives were therefore used to focus the thematic analysis to specific parts of the interview data. This approach to thematic analysis aligns with the social constructionist epistemological foundation of this project and as such "seeks to theorize the sociocultural contexts, and structural conditions, that enable the individual accounts that are provided" (Braun & Clarke, 2006, p.85). Each interview was coded, codes were analysed and gathered into themes, themes were reviewed, defined, and refined, and patterns of meaning were related back to the theoretical foundations of this research (Braun & Clarke, 2006).

Findings

Optimistic Sustainable Development Narratives

To support their position as good farmers caring for the environment within competing claims about the environmental impacts of beef production, participants drew upon narratives of necessary reciprocity with nature and examples of management practices that enable economic production along with environmental protection. These narratives heavily incorporate the optimism of sustainable development discourses and the accompanying assumptions. Participants widely recognised their reliance on the health of the environment for continued production. For example, Shawna, a fourth generation producer, explained that while her family cared very deeply for the environment, she could not recall an instance of speaking solely about environmental management. She explained:

> Because really, everything we do impacts the environment one way or another. When we look at operations of this ranch, *the environment is a direct*

> *result of things*. *If we're doing things properly the environment's going to be able to maintain itself*. The better we treat our environment out there the better it treats us. And from that, from a profitability perspective, the better, the healthier the range system, the better, the healthier that cattle are, the more pounds of beef they put on. Everything just falls in line. And it's a chain of events, that if it is being managed properly you can, it's working properly. (emphasis added)

Shawna's sentiments regarding treating the environment well so that the environment will treat the rancher well is indicative of the reciprocal relationship with nature appreciated by most participants. Additionally, her statement introduces the idea that a healthy environment will result from smart business decisions. Actions seen as good for business may come to be seen as good for the environment by default. As a specific example of this belief, when discussing water quality management Stephen noted: "the decision making process - there would have been a combination of - would have probably been initiated by an economic concern first hand. Yep. And fixing it had, there was some synergy in the solution. *An environmental benefit [within] an economic fix.*" Economic incentives for environmental improvements seemed key in driving management practices. This is not to suggest that producers were ignorant of potential harms from their economic pursuits, but for many it seemed there was no problem that could not be managed away. As Henry noted there are several decisions to be made about environmental impacts, such as manure management and riparian area protection. However, he stated quite concisely "will they come into conflict? If they do, I manage them." This confidence contributes to producers' self-perception of achieving economically and environmentally sustainable development.

An essential part of striving for sustainable development is defining what should be sustained. In many situations where participants were the current operators of multi generation operations, the sustained economic business was interpreted as indicative of environmental health. Leo explained "typically in these multi generational family operations, and any other operation, you kind of try to leave the land better than when you found it." Seeing themselves as part of a history of environmentalism is rooted in and reinforces cow/calf producers understanding that for their operations to persist they must

be doing what is good for nature. In some ways, this may contribute to assuming economic indicators also speak for environmental health. In this vein, poor management was seen as a choice - an illogical choice - not an inevitability. Marc expressed this sentiment by explaining that a simultaneous sense of personal responsibility towards nature and drive for business success is necessary. “I think it’s both” he said, “I mean you can’t do one without the other. You can't. I mean, not in the cattle industry. You can't. You can't take and take and take and expect to be there for a hundred year because it wont be there.” Here again, it is evident that conscientious cooperation with the environment is seen as necessary for sustained operations on the land. Michael emphasized the degree to which having a negative environmental impact was a choice in stating that overgrazing, for example, “has more to do with management than it has to do with the cattle themselves.” Participants saw themselves as actively engaged with the pursuit of sustainable development on their land and effective management was seen as the means of achieving continual economic success. The understanding that a given practice that is good for production is, by default, good for the environment through a reciprocal relationship with nature, combined with the belief that any environmental harms can be managed away, allows producers to pursue continual economic production without relinquishing their claims of stewardship.

Additionally, the production of food in a sustainable manner was a critical aspect of the good farmer narrative participants drew upon in supporting their economic goals and environmental claims. Chris summarised this idea, with respect to contributing to the world in a number of ways:

> I can preserve the most endangered ecosystem in the entire world using [native prairie] and feed people high quality food while I do it. So that to me is, it's, I mean - anything environmental is always great - but to me that's, in my mind is black and white. I can actually make that resource better and feed people at the same time. I just think that's kind of neat.

Many participants not only saw themselves as producing food, but as producing food with low inputs. As Justin explained, this is seen as a necessary pursuit for producers: “if as an industry if we don't improve and do these sort of things - get more out of our cows, get more out of our carcasses, even the crops, get more out of the crops - there's going to

be a huge portion of the population that starves." These social and environmental justifications help producers stand their ground when competing claims of the environmental impacts of the beef industry arise. The emerging rationale follows that if production is necessary to feed the world, pursuing production is positive. Further, if production requires a healthy environment and production is increasing, the environment must be healthy. Many participants spoke of seeking win-win situations such as this.

Genomics, as a management tool to enable food production with fewer resources, fits into this mentality. Only a small number of participants were actively involved with the application of genomics in their operations. However, while many producers were not familiar with genomics per se, most participants, when presented with a hypothetical opportunity to more accurately breed their animals to grow more while eating less, saw merit in doing so. Gerald, a participant who had received some genetic information on his animals but remained skeptical of genomics improving breeding decisions overall, noted "obviously, an animal that converts better, uses less feed to put on the same amount of gain, is going to be more environmentally compatible." Similarly, Henry saw a future for genomics in the industry but was not currently involved. He echoed a common sentiment, saying "Oh, it's great if it could be used to do that. I believe methane is an energy source and as such if the energy can be kept in the animal it probably causes the animal to grow at better rates and anything else - the energy could be used by the animal. So feed efficiency is an utmost concern." Feed efficiency was primarily a concern for economic reasons, again with some environmental benefits. As Justin explained "If you can select cattle that are more efficient than others then that affects your bottom line. And, on the flip side, it affects the environment too." Michael, however, summarised the economic incentives most succinctly:

> Any bit helps. What I'm saying is, there's nothing wrong per se with promoting the net feed efficiency from that [emissions reductions] stand point, right? For me as a producer it's more about the economic advantages of feeding less feed to my animal than it is necessarily [about the environment]. I guess, I mean that's a selfish view, but the reality is that 99% of people are going to see it that way.

The economic benefits seem to stand out as incentives, but, as with other practices, improving the environment at the same time is something producers find appealing. Additionally, for reasons explored further below, feed efficiency was generally seen as a means of protecting the local environment, which is linked to economic success, more so than a means of reducing the beef industry's contributions to GHG emissions and climate change. Genomics within the beef industry is being proposed as a win-win situation, in keeping with the optimism of sustainable development from an ecological modernisation approach. Participants in this study shared this optimism of being able to produce and protect the environment and acknowledged increased feed efficiency in their cattle as one contributing practice; the degree to which they accepted genomics as a means to achieving their sustainable development goals varied. On an individual level, many participants were cautious of what they described as the beef industry's propensity to rely on technology for sustainable development. Thomas explained:

> And there's also the exposure of the technology being used as a silver bullet. Because that is the modus operandi of my industry. We grab onto something and this is the new thing! We chase part way up this hill and then look over there and go, wait a minute! That's it! The flag waves and we go grab that one and go up that hill. The cattle industry has been extremely fickle in terms of trying to keep its focus on where it's going. In, in true reality they chase the dollar. And that's what gets them into problems. When you chase the dollar, that's the economic side of the stool. The environmental and the social side fall off and the stool falls over.

In this regard, while feed efficiency was deemed part of a sustainable future, genomics was considered but one tool in a full tool kit of practices.

Overall, narratives focused on sustainable development – sustained economic production, facilitated by and facilitating environmental protection – were shared by participants. While the environmental degradation suggest that negative impacts are occurring at least in part due to individual producers' practices, producers maintain their self-perception as stewards by explaining they could not be successful if they were anything other than good to the environment. Broadly, participants used these narratives to support producers' positions within competing claims. To more fully understand how

these claims are held with a degree of legitimacy alongside competing claims of environmental harms, we must also explore the means by which producers construct and use these narratives to negotiate their position within a system that causes environmental harms.

Knowing Environmental Impacts: Locality and Distance

Locality was an integral theme within the narratives of stewardship and sustainability shared by participants. A deep appreciation for and connection to the land was undeniably evident throughout the interviews. Jack put it most bluntly: "It's part of who and what you are. And you don't exist on the land very long when you're not an environmentalist. That's my favourite saying. We [ranchers] were the original environmentalists. And environmentalists before it was cool." In this context, being an environmentalist was frequently equated with leaving the land – one's own land – better than it was presently. Many participants mentioned their role in making sure the land was better than they had found it and saw cattle as essential to achieving this goal. Proximity to environmental impacts and improvements on their own land provided producers with distinct material experiences that were both influenced by and influencers of the sustainable development narratives used broadly to support their positions as stewards. Frequently, participants provided specific examples of improvements to their land resulting from conscientious management practices. These included improving soil quality, increasing soil water retention, the maintenance of large green spaces, and creating habitat for various wildlife such as ungulates, birds, and pollinating insects. With local improvements to the land, tangible evidence was of utmost importance in producers' narratives. Thomas explained, comparing landscape level improvements to climate change efforts:

> Climate change is such a concept. Out there. It's really hard. Where do you put a stake in the ground or a benchmark? Where do you put a benchmark in that says, I'm 2% better, I'm 20% better, I'm 5% worse? It's extremely difficult, if not impossible, whereas, on this land base I can go into the valley here and look at this creek. And say, do I have clear water that runs all the time? Do I have a healthy environment? Do I have healthy rangelands? Are

> my animals healthy? Those things, those things I can actually gauge. I can stick a stake in the ground and I can see I'm losing ground. I'm gaining ground. You have the evidence.

Improvements to the local landscape from increased feed efficiency were also noted as being measurable and tangible. Stephen noted that emissions were a difficult way to gauge improvements:

> But on issues that we can measure, such as land use, fertilizer usage, which translates into fossil fuel usage, all those things, those are very measurable benefits. Any efficiency gains will reduce our utilisation of those resources and so that's very positive. That one we can take to the bank today.

Evidence of a healthy environment also provided many participants with a sense of pride. For example, Leo excitedly shared stories of field days on his land where specialists come and identify different species of grasses, birds, and insects. Warren also provided examples of increased biodiversity on his land due to his efforts to plants diversified shelterbelts to create micro-climates and habitats. Producers valued these types of local environmental features as positive environmental aspects of their land. The physical realities of experiencing measurable improvements to the land reinforced the perceived environmental benefits of cow/calf production.

In addition to improvements made to specific environmental goods and services, many participants explained their improvements to the land as occurring through making use of land that was otherwise marginal. In this sense, a productive environment is considered a superior or improved environment. Many participants saw cattle as being key to making use of marginal land. Marc, for example, said: "She's gotta make a living for you in the marginal areas that nothing else can making a living in, right? She's not like a chicken or a hog that goes into a barn and everything is provided from the grain farmer. The cow business is all about trying to make something out of nothing." Several examples of grazing cattle causing healthy disturbance and contributing nutrients through natural fertilization and trampling were shared. These examples contributed to participants' explanations of how having cattle on land that can not produce crops improves upon what is naturally present. While discussing advantages of beef production, Stephen noted:

> The other advantage - and I'm not sure if this is environmental, maybe it's a little more economic, I think they dovetail in that those areas are not particularly beneficial for any other use, certainly not for agriculture and so they're maintained in a very natural state and you know there's small but some economic benefit derived from them.

Stephen's comments are indicative of the perception that economic and environmental advantages are achieved via the presence of cattle on the local landscape. This perspective contributes to negotiating a position of caring for the environment by conceptualising a healthy environment as one that is productive and relatively natural.

Participants' understandings of their contributions to the natural environment call upon their knowledge of and ability to act upon the physical, material qualities of their land. As such, the locality of stewardship was tied to feelings of agency. As they had the most intimate knowledge of their own land, many producers felt the most capable and powerful to impact change on their own land. Within their own operations, the application of locally based expertise and real world experience was highly valued. Michael spoke of the importance of having personally experience with ranching when developing management practices:

> It's like anything, if you haven't ever done it how are you supposed to tell somebody else how to do it? Because number one, yeah, you can read out of a book but there's all the little nuances. You can read it out of a book that says do this, this, this, and this but what happens when this happens? Well, you have no clue because you've never had that happen to you, right? So, to get any sort of respect usually you have to have some sort of real world experience.

Each participant drew from their material experiences on the land to develop expertise and a sense of power with respect to their ability to manage their own land. Because, as George explained, best management practices are not one size fits all, active application of local knowledge was perceived as essential to continued success. When seeking environmental management practices to address a given issue or improve production participants viewed custom fit practices, developed with knowledge of the unique

features of their own land base, as ideal. Chris emphasized the importance of maintaining agency in choosing local environmental practices:

> I might look at whether there's funding to do some of the stuff but I wouldn't give up my creative flexibility just to get the funding. There are lots of times there's funding to do some environmental projects through Growing Forward[1], a lot of times there are restrictions on it. I would just pay my money out of my own pocket so I could do it in a way that works here, rather than fitting all the criteria that I'm told I need to do.

Chris and many others felt that it was important for individuals with knowledge of the local land to be in control over management practices. Most participants noted they were willing to consider ideas from anyone but could modify practices to better suit their particular environments. Many participants therefore sought advice from producers with practical experience, close to home. Some met with a group of producers in their community on a semi-regular basis to discuss what each person was doing, what was going well, and what had not worked. These meetings typically occurred at one of the group members' farms and often included a field tour to see physical changes or practices. Locality emerged as critical in producers' ability to understand the environment and experience agency in their application of this knowledge. Examples of positive action when and where they are able may contribute to producer narratives that reconcile their participation in a system that causes harm; the application of what they have materially come to know provides a sense of having done one's part.

However, with the connection between locality and stewardship comes a disconnect when environmental impacts are not or cannot be felt locally. An environmental impact occurring elsewhere is not tangibly experienced by producers, is not measured by producers, and is not understood through local, embodied knowledge. Discussions of climate change and the use of genomics in reducing GHG emissions brought this distinction to the forefront. Participants described methane emissions from cattle, climate change, and the use of genomics to reduce GHG emissions as obscure, abstract, and unquantifiable. In addition to their own inability to measure changes to

[1] Growing Forward is an initiative of the Government of Alberta that seeks to provide programs and services to facilitate a profitable and sustainable agriculture industry in Alberta (http://www.growingforward.alberta.ca).

emissions, many participants were skeptical of the science measuring emissions from cattle. Further, climate change was not an environmental impact from beef production for which producers felt there was adequate evidence. George conceded that some unseen impacts occur and summarised the views of most participants:

> I am aware that there are things that we are maybe doing that cause effects that we don't see. And I'll take some of that on faith. And I'll trust that the scientists will do their work. I trust them to be bigger picture thinkers, I trust them to put this in context. But with the amount of arguments I hear going on out there my trust is waning. My perception of greenhouse gases is somewhat cloudy. I'm saying this as me a cattleman and me as a professional: *it is a quantum leap from my cattle burping to global temperatures increasing.*

With large scale phenomena such as climate change, producers lacked a tangible evidence to suggest their cattle were part of the problem. While contributions to climate change remained abstract and were thereby disregarded, climate change mitigation measures naturally in place on their land were touted by producers as important. Philip spoke on this note: "This operation for example, cows produce methane and I capture a pile of carbon too, in my practices, which balances it out." Jack added, "God put that grass on this earth to get rid of the carbon and everything. And it works." In contrast to methane emitted, producers can observe material contributions to carbon sequestration through continual grass production and minimal soil disturbance. The combination of a lack of connection to negative emissions related impacts and connection to positive sequestration impacts exemplifies the role of locality in influencing management practice adoption. Overall, while many producers are willing to go as far as to say everyone ought to do their part to reduce GHG emissions, targeting emissions from their cattle was not deemed a priority.

When asked if using genomics with the intent of decreasing the GHG emissions from cattle was a worthwhile pursuit, producers generally said that it was not. However, when asked if increasing feed efficiency was a worthwhile pursuit, responses were consistently positive. Stephen laid it out as such:

> The benefit, I think of, of feeding cattle that are more efficient in the feedlot is profound, both from an economic standpoint and from and environmental

> sustainability standpoint. *Not only from a greenhouse gas emissions standpoint, which is a benefit, but in my view probably the least of, even from an environmental standpoint* because in it when cattle are consuming less grain to put on a pound of beef, there is uh, less land utilised, less fresh water utilised. Yes, yes, fewer greenhouse gases emitted. But the environmental benefit becomes almost exponential through all of it. So that's very important work.

The environmental benefits Stephen, and others, referred to in this regard are measurable, material experiences. William spoke to the importance of explaining the benefits of genomics as such in order to get producers to adopt. He suggested presenting the use of genomics as increasing feed efficiency with material benefits primarily and methane emissions reductions as an added bonus. Real world experiences with improved feed efficiency, such as reduced feed costs, reduced grazing, and easier manure management were discussed as tangible reasons for adoption. In this sense, attempting to improve feed efficiency through whatever means available was sensible. The degree to which producers felt genomics was necessary or contributory was les concrete. For example, many producers viewed the additional accuracy and predictability of breeding informed by genomics favourably but considered it cost-inhibitive at present and/or thought the science was not quite at an applicable level yet.

Producers seem to draw from their immediately local, material experiences in negotiating and reconciling their participation in a system that contributes to environmental degradation. Participants' emphasis on examples of environmental protection and improvements on their own land privileges a bounded understanding of environmental impact. The locality of tangible effects enables producers to incorporate selective environmental impacts into their self-perception while excluding others. Personal narratives of sustainability may therefore remain unquestioned by producers.

Fragmented Discourses of Sustainability

As argued above, producers draw upon local, material experiences to support their claims of stewardship and sustainable development. However, fragmented discourses of sustainability precipitate due to the bounded nature of these material-focused narratives.

Drawing from their own material experiences, producers differentiate themselves from other agricultural sectors and industries and justify their own prioritization of economic factors by positioning themselves as the *more* sustainable option. Frequently, experiences on their land enabled producers to naturalise the presences of cow/calf operations. Leo outlined commonly used comparisons of cattle to buffalo and contrasted this to crop based agriculture:

> When you consider that this environment evolved and the plant species evolved since the last ice age with grazing animals, the cow/calf thing kind of fits in that. The buffalo are gone and that's where [we fill in]. There are buffalo skeletons around here everywhere. And so, well-managed native grass I think is very much a plus for the environment. Rather than ploughing it up.

Gerald also summed up the sentiments of how beef production was a natural fit and therefore a more than justified presence on the landscape:

> I'm a strong advocate of the beef cow because she is one of the very few industries that actually goes out, harvests, and returns a product back to the yard without any inputs. And, when she is done you can harvest the factory. So, as far as being environmentally in sync, I think all that it is a domesticated form of the bison and a way to harvest the solar energy without utilizing a whole bunch of outside resources.

Many participants had come to see their cattle as filling an ecological niche by providing the grazing disturbances previously caused by buffalo and ungulates across the prairies. In many producers' perspectives the presence of cow/calf operations facilitated this ecological service, whereas other uses of the land likely would not. Such constructions of natural were self-serving insofar as they informed producers' self-perceptions as sustainable.

Participants continued to differentiate themselves from other industries when discussing genomics and the methane emissions from cattle. Within the beef industry, feedlots were seen as the source of emissions, not cow/calf operations. Producers drew upon their material realities to explain this. Grazing cattle on cow/calf operations were compared to natural ungulates, as presented by Bruce. When asked if he thought he ought

to try to reduce the emissions from his cattle he stated: “No. I think we should just leave it alone to be honest. If you're going to pick on the cow then you have to pick on the moose and the deer and the elk and everything else. Mother nature has got a whole whack of them out there and you can't control them.” In feedlots, cattle are fed grains, a practice that was largely considered less sustainable than grazing. Justin’s father explained: “one of the things that we know is, cattle upon grass, their emissions are less, as compared to say a feedlot. So, the longer that we can keep them on grass, or keep them in the field, the better.” Diet, rather than genetics, was the observable factor allowing participants to frame their cattle as sustainable. Many participants anticipated that additional changes to feed efficiency to be attained through genomics would be demanded from feedlots rather than prioritised at the cow/calf level without outside pressure. Furthermore, the beef industry overall was seen as contributing less to climate change and environmental degradation than crop production and energy industries. Fragmented discourses of sustainability are evident here in terms of scale as well as in terms of constructions of that which is natural; producers considered emissions from their individual operations and could therefore discount their own impacts while considering the emissions from other sectors and industries on a cumulative, systemic, and thereby more obviously unsustainable scale.

When negotiating their position as stewards despite participation in a production system that causes harm, participants relied on these differentiations – comparisons to that which they were better than – to inform their sustainable development discourses. Possible land uses were presented as either cow/calf production or something worse. For example, Leo explained the land development options where he operates as “it can grow cows or grow houses and I don’t want to grow houses.” Other participants suggested that their land would be used for recreation if it weren’t producing cattle; in this case the land would be subject to harmful disturbances from ATVs and insufficient ‘natural’ disturbance from cattle. Crop based agriculture on the same land was considered unsustainable in its alteration of the natural environment and high input requirements. As such, participants understood their presence as barrier to land degradation. However, the continued presence of cow/calf operations on the landscape to act as a barrier to more harmful developments is contingent on their ability to maintain livelihoods. Therefore,

producers were forgiving of prioritising economic success and less than perfect environmental practices. In many circumstances, prioritising economic factors was viewed as a pragmatic necessity but was not taken lightly, such as for Leo, who said:

> Well, sadly you have to consider economics because we've got to be able to afford to do it. But I've kind of given up that there will ever be any serious money in the cattle business. So once you get past that, it tends to be not so much an economic decision, and more of a decision whether I can afford it or not. Because the pay back might be a long time, if there is one, but the satisfaction of doing what you think is the right thing is instant.

This statement presents the necessity of not being at a financial loss in pursing environmental improvements in order to continue one's operation. However, the acknowledgement that ranching is a business endeavour was also prominent. For example, George stated, "in day-to-day business I am always looking for practice change that will *improve my business sustainability*, help me make more money, in a more risk proof fashion, that is at least neutral with respect to the environment." Business sustainability was considered a precursor to remaining on the land and thereby preventing a more harmful activity. By deploying fragmented discourses of sustainability participants forgave individual cow/calf operators' profit-based motivations but did not afford the same leniency to other industries.

Discussion

The literature exploring farmers' values of caring for the land as well as the land degradation caused by industrial food production emphasizes the importance of both social (Burton *et al.*, 2008; Ellis, 2013; Silvasti, 2003) and material (Carolan, 2006; 2008; Redclift, 2005; Urry; 2000) realities to understand this disconnect. To date, analyses of the disconnect between land degradation and farmers' values suggest: an unwillingness or inability to recognise and act upon environmental harms due to farmers' valuing agriculture as ecological (Ellis, 2013; Silvasti, 2003); the association of production with a good-farmer identity (Burton *et al.*, 2008); and on-farm embodied experiences and knowledges that result in farmers seeing a specific landscape as valuable and thus certain

behaviours as appropriate, or ecological, though researchers or policy makers may disagree with this assessment (Carolan, 2008; 2008; Greider & Garvovich, 1994; Urry, 2000). More broadly, sustainable development theories identify applications of sustainable development discourses that enable economic development to be prioritised at the expense of the environment while still allowing environmental values to be claimed (Imran, Alam, & Beaumont, 2014; Seghezzo, 2009; Redclift, 2005). Building upon the literature, this research elucidates a cyclical merging of these possible understandings of producer narratives into a new perspective. Overall, producers' experiences on the land are influenced by sustainable development narratives and producers' conceptualisations of sustainable development are informed by their social and material experiences. This iterative cycle creates space for producers' claims regarding their environmental caring to hold legitimately alongside claims of system-wide environmental degradation.

Creating Space for Competing Claims

This study contributes to the literature by critically invoking sustainable development theory to better understand the environmental management practices of agricultural producers. Specifically, I suggest that sustainable development narratives contribute to creating the space in which claims of both environmental degradation and stewardship co-exist. The pro-environmental values of 'the good farmer' seem to be incorporated into broader sustainable development narratives that do not necessarily serve the best interests of the environment. As is suggested in the literature, I find sustainable development is accepted by participants as normative and has become a part of a shared understanding and sense of how producers are located within a broader system of production and environmental stewardship (Luke, 2005). As such, sustainable development narratives affect how producers come to see their surrounding environment as a specific landscape incorporating social and physical experiences (Freudenberg *et al.,* 1995; Greider & Garvovich 1994). Participants see the natural environment and their business environment as a single whole that cannot be disentangled and that can be managed such that economically and environmentally win-win situations are probable. The idea that management decisions can solve environmental disruption is common in sustainable development narratives that are grounded in capitalist production where the

environment is seen as a pool of resources and environmental sustainability is viewed as contingent upon economic success. As noted by Goldman and Schurman (2000) "in the semiotic shift toward the capitalization of nature, environmental degradation and resource exhaustion are being diagnosed as management problems rather than as a crisis or breakdown; this management exercise then becomes a new source of dynamism for capitalism" (p. 567). The fact that producers do not question production in the face of environmental harms is evidence of this phenomenon and is abetted by sustainable development narratives. This is exemplified in producers' perceptions of the use of genomics to achieve increased feed efficiency in their herds.

With regards to the role of biotechnology in sustainable development or sustainable agriculture, most participants were tentative and moderate in their stance. Genomics was often described as a tool and participants offered warnings of genomics "not being a silver bullet." In this regard, producers questioned the optimistic role for technology in sustainable development as it pertains to the beef industry. In contrast, increased feed efficiency fit comfortably within participants' sustainable development narratives; environmental benefits could be achieved through the pursuit of increased economic success. On one hand this use of genomics may enable environmental improvements through GHG emissions reductions and reduced feeding pressures. On the other hand using genomics to increase feed efficiency serves to reinforce assumptions of sustainable development that fail to adequately protect the environment on a broader scale. Sustainable development narratives encourage the pursuit of this type of management to solve both economic and environmental problems. Genomics may be helpful as a way to to reduce environmental harms in beef production. However, it seems this technology also supports a status quo wherein the sustainable development narratives that guide individual actions do not adequately address environmental sustainability and producers remain disconnected from the beef production system. Therefore, while genomics addresses the problem of methane emissions from cattle, the use of this technology comes with challenges in terms connecting individual producers to and encouraging them to act upon additional system based environmental harms.

Overall, it seems farmers' values of stewardship alone do not mask environmental harms or power relations. Nor are productivist values the sole culprit for insufficient

environmental protection. This research suggests we ought to consider the possibility that system wide environmental degradation is facilitated by these values couched in and justified by sustainable development narratives.

A Materially Informed Cycle

The second way this research contributes to the literature is by building upon work focused on materiality and locality and merging these ideas with sustainable development theory. In particular, I suggest material experiences assist producers in maintaining their self-perceptions as stewards and conceptualizing sustainability in ways that cater to these self-perceptions. Locality was found to be an essential factor in shaping producers' understanding of the environment, their environmental practices, and sustainability. By equipping producers with the means of negotiating their position as stewards and reconciling their participation in a system that causes environmental degradation, local, material experiences further create space for competing claims regarding the environmental impact of beef production to co-exist and remain unresolved. Abstract or cumulative effects are not known to producers in a material way and are therefore not the focus of producers' environmental efforts. This outcome supports Carolan's (2008) suggestion that epistemic distance is a barrier to increased environmental sustainability. Being only known of from afar, as opposed to known corporeally, removes issues such as GHG emissions from many producers' sensibility and perceived agency. This is exemplified through producers' interest in genomics for landscape-level improvements rather than climate change mitigation. However, decision-making based on immediate, material environments may, as Urry (2000) notes, contributes to producers acting "far from equilibrium" (p.197) in terms of achieving environmentally benign production and thus contributes to the observed system-wide degradation. In this case, locality informs the sustainable development narratives that then impact producers' preferred landscapes and desirable actions. Further, drawing from local experiences producers differentiate themselves by focusing on their individual impact relative to the system wide impact of other sectors and by naturalizing the presence of cattle on the landscape. These fragmented discourses of sustainability may permit producers to see themselves as a barrier to environmental degradation from more

harmful industries and thus both justify their continued presence on the land and the means by which they enabled this continued presence through economic success. The co-existence of competing claims regarding environmental impacts from the beef industry can be better understood by taking into account the cycle described above. Producers' sense of caring for the environment is shaped by narratives that forgive sacrificing environmental health to pursue economic gains and is informed by examples of positive environmental impacts that exclude a system-wide perspective.

Conclusion

The theoretical and analytical frameworks used to explore interviews with cow/calf producers in this chapter facilitate an understanding of the narratives producers draw upon and how they use these narratives to explain their claims of caring for the land alongside competing claims of the beef industry contributing to environmental degradation. Participants' development and application of these narratives was explored through their decision making with respect to an emerging environmental management practice: the use of genomics to selectively breed for increased feed efficiency and associated reduced GHG emissions and reduced feed production pressures. The findings present cow/calf producers' broad use of sustainable development narratives in staking claim to their positions as stewards and the use of locality and materiality in arguments to substantiate this claim. Fragmented discourses of sustainability are observed as cow/calf producers differentiate themselves and their environmental impacts as natural and as relatively less harmful than other sectors. An iterative cycle of sustainable development narratives shaping how producers come to know and experience the land and local environmental experiences shaping sustainable development narratives supports producers' self-perception as stewards by reifying a discourse of sustainability that is disconnected from the industrial beef production system as a whole.

It is beyond the scope of this research to determine the validity or impact of participant producers' environmental management efforts; overall though, it is evident across the beef industry that environmental sacrifices are being made on cow/calf operations at a significant enough frequency to contribute to system-wide environmental

harms. This research provides insight into the rationale and arguments of producers who may be resistant to accepting responsibility for these environmental impacts and thus may contribute to more fruitful dialogue and progress surrounding individual producers' role in reducing the system wide negative environmental impacts from the beef industry. Future research could build upon our understanding of fragmented discourses of sustainability as a barrier to environmental impact reduction in the beef industry or other settings. More in-depth understanding is necessary to address and overcome the cycle identified herein. These findings suggest future research ought to consider the role of local, material experiences in social constructions and applications of sustainable development and develop means of overcoming the associated barriers. In terms of practical next steps, proponents of genomics can build upon this research by considering the ways in which they frame the benefits of genomics such that cow/calf producers see merit in adopting. However, this research emphasizes the need to reflect on the implications of technological solutions such as genomics and the risks associated with failing to address systemic environmental challenges.

References

Alberta Cattle Feeders Association. (2014). *Beef production in Alberta*. Retrieved from http://www.cattlefeeders.ca/industry/production.aspx April 25, 2014

Banerjee, S. B. (2003). Who sustains whose development? Sustainable development and the reinvention of nature. *Organization Studies*, *24*(1), 143-180.

Beauchemin, K. A., Janzen, H., Little, S. M., McAllister, T. A., & McGinn, S. M. (2010). Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. *Agricultural Systems*, *103*(6), 371-379.

Bell, M., Wall, E., Russell, G., Simm, G., & Stott, A.W. (2011). The effect of improving cow productivity, fertility, and longevity on the global warming potential of dairy systems. *Journal of Dairy Science*, *94*, 3662-3678.

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*, *10*(2), 141-163.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Burton, R. J. (2004). Seeing through the 'good farmer's' eyes: towards developing an understanding of the social symbolic value of 'productivist' behaviour. *Sociologia Ruralis*, *44*(2), 195-215.

Burton, R., Kuczera, C., & Schwarz, G. (2008). Exploring farmers' cultural resistance to voluntary agri- environmental schemes. *Sociologia Ruralis*, *48*(1), 16-37.

Carolan, M. S. (2006). Do you see what I see? Examining the epistemic barriers to sustainable agriculture. *Rural Sociology*, *71*(2), 232-260.

Carolan, M. S. (2008). More- than- representational knowledges of the countryside: How We Think as Bodies. *Sociologia Ruralis*, *48*(4), 408-422.

Daly, K.J. (2007). Epistemological considerations in qualitative research. *Qualitative Methods for Family Studies & Human Development*. Ed. K.Daly. Thousand Oaks: Sage. pp.19-27.

de Haas, Y., Windig, J.J., Calus, P.L., Dijkstra, J., de Haas, M., Bannink, A., and Veerkamp, R.F. 2011. Genetic parameters for predicting methane production and

potential for reducing enteric emissions through genomic selection. *Journal of Dairy Science 94*, 6122-6134.

De Schutter, O. (2014). *Report of the Special Rapporteur on the right to food, Olivier De Schutter, Final Report: The Transformative Potential of the Right to Food.* United Nations General Assembly.

Dobson, A. (1996). Environment sustainabilities: an analysis and a typology. *Environmental Politics*, *5*(3), 401-428.

Ellis, C. (2013). The symbiotic ideology: Stewardship, husbandry, and dominion in beef production. *Rural Sociology*, *78*(4), 429-449.

Freudenburg, W. R. (2005). Privileged access, privileged accounts: Toward a socially structured theory of resources and discourses. *Social Forces*, *84*(1), 89-114.

Freudenburg, W. R., Frickel, S., & Gramling, R. (1995). Beyond the nature/society divide: Learning to think about a mountain. *Sociological Forum 10*(3), 361-392

Garnett, T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers. *Environmental Science & Policy*, *12*(4), 491-503.

Goldman, M., & A. Schurman, R. (2000). Closing the "great divide": New social theory on society and nature. *Annual Review of Sociology*, *26*(1), 563-584.

Greider, T., & Garkovich, L. (1994). Landscapes: The social construction of nature and the environment. *Rural Sociology*, *59*(1), 1-24.

Heller, M. C., Keoleian, G. A., & Willett, W. C. (2013). Toward a life cycle-based, diet-level framework for food environmental impact and nutritional quality assessment: A critical review. *Environmental Science & Technology*, *47*(22), 12632-12647.

Horlings, L. G., & Marsden, T. K. (2011). Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'. *Global Environmental Change*, *21*(2), 441-452.

Imran, S., Alam, K., & Beaumont, N. (2011). Reinterpreting the definition of sustainable development for a more ecocentric reorientation. *Sustainable Development*.

Knoblauch, H. (2005). Focused ethnography. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, *6*(3).

Lang, T., & Barling, D. (2013). Nutrition and sustainability: an emerging food policy discourse. *Proceedings of the Nutrition Society*, *72*(01), 1-12.

Lele, S. M. (1991). Sustainable development: a critical review. *World Development*, *19*(6), 607-621.

Luke, T. W. (2005). Neither sustainable nor development: reconsidering sustainability in development. *Sustainable Development*, *13*(4), 228-238.

McGuire, J., Morton, L. W., & Cast, A. D. (2013). Reconstructing the good farmer identity: shifts in farmer identities and farm management practices to improve water quality. *Agriculture and Human Values*, *30*(1), 57-69.

Mebratu, D. (1998). Sustainability and sustainable development: historical and conceptual review. *Environmental Impact Assessment Review*, *18*(6), 493-520.

Nguyen, T. T., Hermansen, J.E., & Mogensen, L. (2010). Environmental consequences of different beef production systems in the EU. *Journal of Cleaner Production, 18*, 756-766.

O'Riordan, T., & Voisey, H. (1997). The political economy of sustainable development. *Environmental Politics*, *6*(1), 1-23.

Paarlberg, R. (2010). *Food Politics: What Everyone Needs to Know*. New York, NY: Oxford University Press.

Raymond Park, J., McFarlane, I., Hartley Phipps, R., & Ceddia, G. (2011). The role of transgenic crops in sustainable development. *Plant Biotechnology Journal*, *9*(1), 2-21.

Redclift, M. (2005). Sustainable development (1987–2005): an oxymoron comes of age. *Sustainable Development*, *13*(4), 212-227.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological economics*, *48*(4), 369-384.

Seghezzo, L. (2009). The five dimensions of sustainability. *Environmental Politics*, *18*(4), 539-556.

Shiva, V. (2000). *Stolen Harvest: The Hijacking of the Global Food Supply*. Cambridge, MA: South End Press.

Silvasti, T. (2003). The cultural model of "the good farmer" and the environmental question in Finland. *Agriculture and Human Values*, *20*(2), 143-150.

Statistics Canada. (2014). Table 003-0032 Number of cattle, by class and farm type. *CANSIM*. Retrieved from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0030032&tabMode=dataTable&srchLan=-1&p1=-1&p2=9

Tan, M., Tan, R., & Khoo, H. (2012). Prospects of carbon labeling – a life cycle point of view. *Journal of Cleaner Production*, *72*, 76-88.

Urry, J. (2000). Mobile sociology. *The British Journal of Sociology*, *51*(1), 185-203.

Chapter 3 - Beyond Trust in 'the Science': How Multiple Social and Interpersonal Trust Scenarios Impact Cow/calf Producers' Perceptions of Genomics

Introduction

Emerging science and technology are often introduced to the public as positive advances in human knowledge and ability. However, the social and physical realities of the adoption and impact of science are markedly more complex and varied. In agriculture for example, biotechnologies are understood from many perspectives – researchers', policy makers', producers', and publics' – that result in a spectrum of perspectives ranging through fear, curiosity, and optimism (Paarlberg, 2010). Some of these biotechnologies are among the proposed solutions to concerns with environmental impacts of various aspects of agriculture. Currently, genomics is presented as a means of reducing the environmental impact of beef production. Briefly, genomics is "the science that studies the structure and function of genomes and, in particular, genes" (van den Heuvel *et al*., 2006, p.345). Researchers in this area suggest the use of genomics in selective breeding enhances traditional breeding processes by providing genetic information sooner than would be evident through visually observed traits alone (Bell *et al,*. 2011; de Haas *et al*., 2011). Of particular interest in this study is the use of genomics to selectively breed for increased feed efficiency - better digestion - in cattle. These traits could have the effect of reducing methane emissions and alleviating grazing and feed production pressures (Bell *et al.*, 2011; de Haas *et al.*, 2011). Currently, the science of genomics has growing applicability within the beef industry but the social aspects of adopting this technology are less well understood. The complexity of both the science and the beef industry represent an interesting context to explore producers' and researchers' perceptions and the social context of adoption with a focus on trust.

The negative environmental impacts of beef production are of growing popular concern, with a recent study labeling beef as the least sustainable meat (Eschel *et al.*, 2014). In the face of these environmental challenges, genomics holds the promise of contributing to multi-faceted impact reduction efforts. The adoption of genomics,

however, (as with other technologies) demands more than workable innovation and scientifically robust evidence. In the advent of a new technology or practice a number of social and psychological factors may influence adoption. In addition to laboratory science, institutions and social relationships are integral to the taking up of innovations by individuals and communities (Herring, 2007; Rogers, 1962; Wynne, 1992). Drawing on longstanding scholarship on the diffusion and adoption of innovation, research suggests individuals' awareness, interest, and evaluation of risks and benefits, as well as her/his trial experience on a small scale to test future utility, precede full scale adoption (Rogers, 1962). The public's understanding of science and the role of trust therein are key aspects in these stages of the diffusion of innovation and are the focus of this paper. Individuals' understanding of science and technology is well established as a significant factor influencing acceptance and adoption (Rogers, 1962; Siegrist and Cvetkovich, 2000). Within this stream of scholarship, many studies seek to understand public perceptions of science, technology, and associated risks. The notion that the public simply lacks knowledge or is irrational is widely held among scientists and policy makers (Arvai, 2014). In refuting the assumption of public ignorance, many authors suggest that lay judgments of science and technology are complex and that scientific knowledge is but one of many contributing factors (Hansen, Holm, Frewer, Robinson, & Sandøe, 2003; Roberts, Reid, Schroeder, & Norris, 2011). Trust, for one, has emerged as integral to judgments of risk. Additionally, in various streams of research, trust is identified as influential in farmers' technology acceptance and adoption (Knowler & Bradshaw, 2007; Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008; Wynne, 1992). We are encouraged to consider the interconnected nature of social relationships, trust, and public understandings and acceptance of technology and scientific knowledge. Wynne (1992) notes:

> The best explanatory concepts for understanding public responses to scientific knowledge and advice are not trust and credibility *per se*, but the social relationships, networks and identities from which these are derived. If we view these social identities as incomplete, and open to continual (re)construction through the negotiation of responses to social interventions such as the scientists represented, we can see trust and credibility more as

> contingent variables, influencing the uptake of knowledge, but dependent upon the nature of these evolving relationships and identities (p. 282).

The idea of trust as contingent on social relationships and identities suggests there is more to understanding and accepting scientific information than merely believing the technologies produced will do as claimed in research labs. Real world applications of science involve complex risks, opportunities, and relationships and are rarely apolitical (Herring, 2007). The adoption of genomics in agriculture has complex social and political impacts, involving issues of property, power, and the legitimation of some interests over others (Herring, 2007).

Many social relationships, networks, and identities impact cow/calf producers. Personal and distant relationships with other producers, other sectors, governments, and research institutions simultaneously have an impact on individuals' perception of genomics and the application of genomics in the industry. Thus, the objective of this research is to understand how trust influences cow/calf producers' perceptions of using genomics in the beef industry and in doing so contribute to the literature on trust and public understanding of science. To meet this objective I have asked (1) in what ways do cow/calf producers' and genomics researchers' perceptions of the use and impact of genomics in the beef industry converge and diverge; and (2) how do these perceptions contend with current scholarship on the role trust plays in public understandings of science.

Overall, I find producers present high levels of social trust in scientists and 'the science' at a genomic level. Their concerns lie with the social implications of the application of the science, in part due to low levels of social trust in other sectors with competing vested interests. In this context, interpersonal trust is found to be relevant as it fosters willingness in cow/calf producers to engage with the topic of genomics. The importance of this research lies in its consideration of multiple interpersonal and social trust scenarios. In doing so, this study both builds upon theories of trust in public understanding of science, with a focus on social trust and lay publics. This research also informs beef industry sectors and researchers on the nuances of cow/calf producer interactions with the science and the application of genomics in the beef industry. As much of the existing research addressing public understanding of science juxtaposes

expert and uninformed lay perceptions, this study offers an alternative perspective. This research involves cow/calf producers with significant experiential knowledge and expertise of their own operations and the beef industry as well as genomics researchers with in-depth knowledge of genomic science and technology. Before examining the case of genomics, the environment, and the Alberta beef industry, I present literature pertaining to the adoption and diffusion of innovation broadly and focus on related theories of public understanding of science and trust.

Literature Review

Rural sociology is but one of many disciplines that focuses on the diffusion and adoption of innovation. Innovations include new ideas, technologies, or practices and diffusion is generally regarded as the spread of these ideas or practices, often through imitation (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). Traditionally "interventions aimed at spreading innovation harnessed the interpersonal influence of opinion leaders and change agents, and research mapped the social networks and adoption decisions of targeted individuals (Greenhalgh *et al.*, 2004, p.589). The encouragement and use of best management practices and many conservation practices are examples of the diffusion of innovation within agriculture (Knowler & Bradshaw, 2007). Over time, diffusion of innovation research has evolved so as to avoid oversimplified early-adopter and laggard stereotypes (Greenhalgh *et al.*, 2004). It is now important to acknowledge each "adopter as an actor who interacts purposefully and creatively with a complex innovation" (Greenhalgh *et al.*, 2004, p.598). Rogers (1967) outlines stages of adoption: awareness, interest, evaluation, trialing, and adoption. These stages are impacted by the innovation itself as well as the individual or firm interacting with the innovation (Greenhalgh *et al.*, 2004; Rogers, 1967). In agriculture, as in other fields, a number of psychological and social factors influence individuals' interest in adopting new innovations (Greenhalgh *et al.*, 2004; Knowler & Bradshaw, 2007; Rogers, 1967). In their review of the literature Greenhalgh *et al.* (2004) build upon Rogers work and identify the following interconnected influences on individuals' adoption: general and context-specific psychological antecedents (such as motivation, skills, tolerance for

unknowns etc.), the personal and social meaning of the innovation, and concerns before, in the early stages of, and after adoption. Others suggest farmers' adoption practices are closely linked with producers' perceptions of how an innovation contributes to their economic, personal, social, and/or environmental goals (Pannell *et al.*, 2006). While acknowledging the complexity of the diffusion and adoption of innovation, this paper focuses on one aspect of the adoption process, the role of trust in understandings of science and the application of scientific innovation.

Public Understandings of Science

Both public understandings of science and scientists' perceptions of public understandings can influence dialogue around and adoption of new technology. These topics are the focus of researchers interested in a variety of fields and technologies. It is well established in the literature that scientists frequently subscribe to a knowledge deficit model when assessing lay understandings (Arvai, 2014). The primary assumption of this model asserts: "if the public does not comply with the advice and recommendations of scientific experts, this is because they have a poor understanding of the scientific reasoning informing that advice, i.e. a 'knowledge deficit'" (Hansen *et al.*, 2003, p.112). As such, many scientists and policy makers involved with technology adoption consider one-way education programs as necessary to "eliminate the laypersons' ignorance" (Hansen *et al.*, 2003, p.113). However, research testing this model suggests knowledge does not play as direct a role as assumed; studies challenging this model find increased knowledge on a subject does not result in increased acceptance (Roberts *et al.*, 2011). Alternative means of explaining public acceptance of technologies have thus been pursued.

Some research focuses on cognitive and attitudinal measurements while other research broadens this inquiry to include social contexts. Research involving psychometric analysis elucidates the multi-dimensionality of perception formation and finds individuals take into account the predictability, probability, severity, and degree of personal control over risks in technology acceptance decisions (Fischhoff, Slovic, & Lichtenstein, 1978; Hansen *et al.*, 2003). Similarly, with respect to agriculture, many studies assess farmers' propensity to adopt new technologies related to best management

practices (BMPs) by considering a number of cognitive, attitudinal, and demographic factors (for an overview of literature on this topic see Knowler & Bradshaw, 2007; Prokopy *et al.,* 2008). While contributing to our appreciation of the complexity of individuals' perceptions of science and technology, psychometric approaches fail to take into account social and cultural contexts and the role of social transformations (Hansen *et al.*, 2003; Wynne, 1992). Thus, increasingly socially situated explorations of public perceptions are deemed necessary (Roberts *et al.*, 2011). Wynne (1992) suggests that people experience scientific information in a way that is not purely intellectual or cognitive but rather "in the form of material and social relationships, interactions, and interests, and thus they logically define and judge the risks, the risk information, or the scientific knowledge as part and parcel of that 'social package'" (p.282). Individuals' judgments of the credibility and trustworthiness of those involved with the development and real-world application of science are "functions of the social networks with which they identify" (Wynne, 1992, p.283). For example, Vanclay (2004) argues "[a]griculture has too long been thought of as a technical issue involving the application of science, and transference of the outputs of that science via a top-down process of technology transfer" (p.213) and we must consider the social and cultural factors both influencing and influenced by technology adoption. As Bickerstaff, Pidgeon, Lorenzoni, and Jones (2010) note, the United Kingdom's 1999 House of Lords Select Committee on Science and Technology recognized that disregarding social and ethical concerns would lead to reduced social trust and subsequently recommended that dialogue with publics become an integral part of scientific processes. However, efforts to engage with publics were ill equipped to actively consider lay publics' socially situated concerns. The research of Bickerstaff *et al.* (2010) suggests that, despite evidence to the contrary, research institutions and policy makers continue to believe public engagement is valuable, first and foremost, as a means to impart scientific knowledge.

The scholarship on this matter however has turned its focus to trust as a critical aspect of public perceptions science and risk. Theoretical concerns of a legitimacy crisis with respect to science came to the fore, in part through the delegitimation of the knowledge deficit model (Roberts *et al.*, 2011). For example, Wynne's research found that farmers' unwillingness to comply with scientists' recommendations were founded in

a distrust of scientists rather than a lack of scientific literacy (Wynne, 1992; Roberts *et al.*, 2011). Concerns of a legitimacy crisis therefore inform a focus on the role of social trust in public understanding and acceptance of science.

Trust and Biotechnology

Trust is fundamentally connected to unknowns, complexity, and associated risks. Thus, the link between public understanding or acceptance of technology and trust is relatively easy to draw. Sztompka (1999) explains, in the advent of new and emerging technologies that create the potential for both widespread benefits and disastrous failures trust is necessary in order for society to cope with vulnerabilities or elements of risk. Consider then, Arnott's (2007) conceptualisation of trust: "a belief in the reliability of a third party, particularly when there is an element of personal risk" (p.981). With respect to the use of a new technology, the third parties may be numerous and their implications of their reliability vary. Expanding upon this idea, trust can be considered "a simplifying strategy that enables individuals to adapt to complex social environment[s], and thereby benefit from increased opportunities" (Earle and Cvetovich, 1995 in Sztompka, 1999, p.25). As such, trust may be considered a functional social mechanism; as noted by Luhmann (1979) "trust, by the reduction of complexity, discloses possibilities for action which would have remained improbably and unattractive without trust – which would not, in other words, have been pursued" (p.25). This is of particular relevance in the context of public understanding of science and the adoption of technologies in complex social environments where not all actors have the same access to information or power.

Niklas Luhmann has theorised trust at length and emphasizes, "trust occurs within a framework of interaction which is influenced by both personality and a social system, and cannot be exclusively associated with either" (Luhmann, 1979). Interpersonal trust focuses on social-psychological interactions between individuals (Earle, 2010; Poortinga and Pidgeon, 2006). Personality, combined with and informed by social and cultural contexts and experiences, influences individuals' propensity to be trusting of both individuals and institutions (Luhmann, 1979). Trust in individuals involves awareness of the personality of another and assurances of the predictability of their actions in keeping with these personal traits (Luhmann, 1979). As interpersonal trust involves interactive

relationships with other individuals, familiarity is both an essential and limiting element of interpersonal trust. The existence and need for complexity, such as in scientific knowledge, create the need for additional system-wide trust (Luhmann, 1979). Many suggest that in modern society trust placed in abstract systems, rather than face-to-face personal relationships, is of growing importance (Roberts *et al.*, 2011).

Social trust is the focus of many 'public understanding of science' researchers as of late (Hansen *et al.,* 2003; Poortinga and Pidgeon, 2006; Roberts *et al.*, 2011; Siegrist, 2000; Siegrist, Cvetkovich, &Roth, 2000; Siegrist and Cvetkovich, 2000). Trust theorists such as Luhmann note that trust is essential to the functioning of expert systems (Roberts *et al.*, 2011). Relative to public understanding of science trust is conceptualised as "the public's willingness to be vulnerable to the actions of the designers, creators, and operators of science on the expectation that they will behave in a way beneficial to the public" (Roberts *et al.*, 2011, p.625). Siegrist *et al.* (2000) have also defined social trust as "the willingness to rely on those who have the responsibility for making decisions and taking actions related to the management of technology, the environment, medicine, or other realms of public health and safety" (p.354). For example, in researching public participation and scientific complexity in a forest management context, Parkins (2010) notes "trust that is based on institutional characteristics, trust that is future oriented and less beholden to the characteristics of individuals, leads to more critically engaged and politically active citizens" (p.835). Numerous studies have demonstrated that trust in institutions is of central importance in perceptions of risks and technology, especially with respect to socially controversial science such as the development and application of biotechnologies (Poortinga and Pidgeon, 2006; Siegrist and Cvetkovich, 2000). In order to allow for consideration of both interpersonal and social trust along with a broad scope of theories pertaining to the mechanisms of trust, I define trust as "a belief in the reliability of a third party, particularly when there is an element of personal risk" (Arnott, 2007, p.981) for the purposes of this paper.

In a meta-analysis of research addressing trust and acceptance of science and technology, Earle (2010) determined that multidimensional conceptualisations of trust are most widely accepted. Care and competence are two dimensions frequently considered (Arnott, 2007; Earle, 2010; Poortinga and Pidgeon, 2006). The care dimension refers to

consideration of the intentions or affect of another relative to certain behaviour or actions. On the other hand, the competence dimension takes into account the ability of another to carry out certain behaviour (Poortinga & Pidgeon, 2006). In this line, Critchley (2008) determined that privately funded researchers are less trusted than publicly funded researchers primarily when controversial science is involve; while perceptions of researchers' competence was consistent, publicly funded researchers were seen to have more benevolent intentions and thus to produce more publicly accessible benefits. In addition to care and competence, the two dimensions of general trust and skepticism are increasingly considered. General trust takes into account both the care and competence dimensions noted above; judgments of general trust take into account past track records, accuracy, knowledgeableness, bias, and public welfare. The skepticism dimension takes into account vested interests, self-protection, and accountability (Poortinga & Pidgeon, 2006). Both general trust and skepticism in government explained a significant portion of the variance in acceptance of genetically modified food in a study in Great Britain; high general trust contributes to trust in risk regulation while high skepticism has the opposite effect (Poortinga & Pidgeon, 2003). Poortinga and Pidgeon (2006) suggest that in a social trust situation, high levels of general trust and high levels of skepticism result in 'critical trust'. Critical trust is suggested to be optimal - a healthy type of distrust - as it causes citizens or affected actors to become actively involved and questioning in their reliance on other persons or institutions (Poortinga & Pidgeon, 2003). Therefore, while the presence of social trust in research institutions and risk management bodies is critical to public acceptance of scientific knowledge and acceptance of exposure to some degree of risk, complete and unquestioned trust may not be personally or societally optimal.

In addition to dimensional conceptualisations of trust, specific mechanisms facilitate the establishment of trust. The literature emphasizes the importance of shared values in facilitating trust. 'Salient value similarity' theories of trust tie perceptions of trustworthiness to the use of heuristics in judgments. This perspective suggests that "people base their trust judgments on whether they feel that the other person or organisation has the same understanding of a specific situation" (Poortinga & Pidgeon, 2006, p.1677). In this sense, perceived relative position of attitudes between actors is relevant in establishing trust. Siegrist *et al.* (2000) support a causal model wherein salient

value similarity results in trust, which then impacts perceived benefits and perceived risks. Poortinga and Pidgeon (2003) determined salient value similarity is particularly important in contexts where familiarity is low, but suggest additional research considering the role of value similarity in trust judgments is necessary. Furthermore, it is also important to consider the relationship between judgments of specific technologies and more general judgments of technology, science, and scientists overall. Poortinga and Pidgeon (2005) conceptualise this relationship as associationist trust and present evidence to suggest that prior association of a technology to good or bad thoughts and feelings most directly influences acceptance. Subsequently, acceptance of a technology influences the degree to which trust in the institutions developing or regulating the technology exists. Drawing from these findings, Poortinga and Pidgeon (2005) suggest that general attitudes are used heuristically to place specific judgments. Roberts *et al.* (2011) found that trust in general science impacts trust in specific sciences or technologies; however, the reverse was not demonstrated. Further, attitudes - such as perceptions of the impact of science on quality of life - not perceived knowledge, were determining factors of trust in general science and technology and subsequently trust in specific technologies. These findings suggest, "fostering positive attitudes towards science plays an important role in developing trust in science and technology" (Roberts *et al.*, 2011, p. 639). Both the salient value similarity and prior-association explanations of the role of trust in technology acceptance engage directly with the function of trust in allowing individuals to cope with complexity. This perspective is, to some extent, in line with the knowledge deficit model adopted by institutions assessing public understanding; it suggests "trust is based predominantly on feelings of agreement and sympathy [and pre-existing attitudes], rather than on carefully reasoned arguments or direct knowledge" (Poortinga & Pidgeon, 2006, p.1675).

In the context of the adoption of innovation within agriculture, the role of trust has been preliminarily explored. However, the majority of this work only quantitatively determines that trust is relevant without exploring how and why within a social context (Knowler & Bradshaw, 2007; Prokopy *et al.,* 2008). Further, the literature on trust in public perceptions of science literature emphasizes the importance of social trust in government and scientists. While valuable, this emphasis excludes consideration of the

multiple interpersonal and social relationships that can impact and be impacted by the application of science and technology in social contexts remains underexplored. This study draws from the literature presented above to explore the role of trust in cow/calf producers' perceptions of genomics and in turn uses the analysis and results to explore the possibility of multiple interpersonal trust scenarios as well as the importance of interpersonal trust.

Methods

This research incorporates the perspectives of cow/calf producers, with experiential expertise in the beef industry, and genomics researchers, with expertise in livestock genomics. This is unique relative to more common comparisons of lay publics' and experts' perspectives. I conducted interviews with 17 cow/calf producers and seven genomics researchers. Thirteen of the producer interviews took place in person, with all but one occurring at the participants' home, and four were by phone. The selection criteria for participation required only that producers be in a decision-making capacity in a cow/calf operation located in Alberta, Canada. The population of cow/calf producers proved difficult to reach through conventional methods; producer organisations with membership lists were unable to distribute contact information or elicit responses from their membership for outside research purposes. Therefore, referral sampling, starting from industry contacts of the researchers, was used to access producers and interviews were conducted until thematic saturation was reached. Referral, or snowball sampling, is considered appropriate in research where participants are difficult to access due to low social visibility' (Biernacki & Waldorf, 1981), such as the participants in this study. In the end, participants were involved with cow/calf operations ranging in size from 25 mother cows to 1200 mother cows, with the majority having between 200 and 500. All participants owned at least a portion of the land on which they operated and a portion of the cattle they grazed. In addition to cow/calf operations, some participants operated feedlots (2 participants), seedstock operations (2 participants), mixed cattle and grain farms (4 participants), and custom grazing services (2 participants). Genomics researcher participants were contacted through a key informant at Livestock Gentec, a University of

Alberta affiliated livestock genomics research centre. Researcher participants included government employees, university professors, and post-doctoral researchers (specific numbers withheld to protect confidentiality). During their interviews, cow/calf participants discussed the role of trust in their environmental management practice decision-making, the ideas for the place of genomics in the beef industry, their perceived risks and benefits of using genomics both for themselves and the industry overall, and the role of trust in genomics-related decision making (see interview guide, Appendix A). Researchers interviewed discussed their roles within genomics research, perceptions of the state of research in terms of industry applicability, perceived risks and benefits to the industry and to cow/calf producers, and perceived impact of producers' feelings of trust on the adoption of genomics (see interview guide, Appendix B).

All interviews, with the exception of one researcher interview, were recorded and transcribed. The participant who was not recorded was pleased to participate in an interview but was not comfortable with the their comments being recorded; notes were taken during this interview, with detailed notes completed immediately following the interview. These data were analysed in NVivo 10 for Mac using theoretical thematic analysis, guided by the research objectives and the theory informing this research (Braun & Clarke, 2006). This approach to thematic analysis aligns with the social constructionist epistemological foundation of this project and as such "seeks to theorize the sociocultural contexts, and structural conditions, that enable the individual accounts that are provided" (Braun & Clarke, 2006, p.85). Each interview was coded, codes were analysed and gathered into themes, themes were reviewed, defined, and refined, and patterns of meaning were related back to the theoretical foundations of this research (Braun & Clarke, 2006). Producer and researcher responses were compared in terms of descriptive content and themes. To protect the anonymity of research participants, pseudonyms are used in reporting study results below with (P) and (R) following the pseudonyms to denote producers and researchers respectively.

Findings

This analysis identifies varying degrees of trust and distrust and brings to the fore the importance of the social impacts of science and technology adoption. The resulting themes differentiate between perspectives of genomics as a science creating predictable tools and perspectives on the social impacts of the application of genomics in the beef industry. I find that while producers' and researchers' views are similar with respect to the science itself, producers' raise a broader spectrum of concerns regarding social impacts. As such, the existence and role of producers' trust varies between these two aspects of their perspectives on genomics. I find producers interest in adopting genomics is impacted by high social trust in scientists, low social trust in other sectors and the industrial system overall, and high interpersonal trust within longstanding individual relationships.

Genomics as a Tool

Producer and researcher participants' views were largely congruent with respect to the potential uses of genomics in the beef industry. Firstly, most participants saw improvements to accuracy and faster receipt of information as the primary benefits of genomics in the beef industry. Sophie (R) outlined the researchers' perspective on the role genomics could play in the beef industry: "the main advantage of genetics is being able to predict an offspring's performance and their value as a breeding animal sooner than what has traditionally been possible." In this regard, researchers did not see genomics as catalyzing much change within the industry. This understanding was noted by Joel (R), for example, who said, "But it's really just adding a little bit more accuracy to the whole breeding procedure that's been in place for many, many years." For the most part, producer participants agreed. For producers who are currently using estimated breeding values (EBVs) or estimated progeny difference (EPDs) genomics was seen as simply improving on what already exists, albeit imperfectly at times. Philip (P), one of many producers to take this stance, stated, "I guess it's another tool, just like EPDs to use where you see fit. But is not going to be the end all." Thomas also expanded on this perspective, noting:

> Our tool box has a few tools in it right now, but every time genomics - genomics is another tool you can drop in there that has a huge package of sub

> tools, you know? So I see them as good things. If you can increase my toolbox, the options, the things I can use to deal with issues that come, environmental issues that come and hit me where I operate, those are good things.

Producers not actively using genomics generally did not press further into the possibilities the technology may offer. The majority of producers expressed doubts as to the current, and sometimes future, utility of genomics for reasons including visual selection skills, anticipated inherent limits to improvements to cattle, and perceived existing gaps in the science. However, many also suggested that as genomics becomes more developed, robust, and applicable for the beef cattle, this technology will inevitably be used throughout the industry. Regardless of position on the scale of future genomics use, most held the position that genomics could be a good option for some producers and many participants echoed Leo's (P) statement "Well, it's something that I'm very glad somebody is doing and I'm very glad it's not me." The producers more involved with genomics currently mentioned additional, specific benefits that researchers also claimed. These benefits pertained primarily to selecting for complex traits that are difficult to physically observe. Chris (P), a producer involved with genomics explained, with this new technology "things like feed efficiency and longevity and disease resistance and all those kinds of things that are tough to measure I can get a picture, I can measure it." This is in keeping with the researchers' perspectives as summarised by Stacey (R): "Well, in fact, genomics is better almost for helping with those complex traits. Because, visually it's difficult to - genomics can actually help you look at all the different genes and all the different factors that affect longevity." These points of convergence between researcher and producer perspectives are focused on the science itself, the degree to which knowledge of the beef cattle genomes, resulting from research, can be successful at improving breeding precision. In this respect, both sides seem to agree on defining genomics as a tool.

In addition to holding similar perspectives on the potential uses of genomics in the beef industry, both researcher and producer participants were pragmatic about the current limitations, especially with respect to traits most beneficial for cow/calf producers. However, acknowledgement of current shortcomings, accompanied by

projections of improvements over time, suggests producers trust the ability of scientists to develop tools that, on a genetic level, will do as claimed. Sophie (R) explained that researchers "pick the low hanging fruit first." In other words, traits such as carcass quality and growth rate have been studied first as they are relatively easy to measure. However, these traits are not necessarily of benefit to cow/calf operations. Many researchers noted that longevity, a trait listed by many cow/calf producers as important to them, is not only difficult to measure but also to define. They noted many single traits contribute to longevity and genomics is able to target these traits but not longevity as a single whole. Carl (R) explained however "it's not up to the farmer to get genomics working for him in longevity. It's up to the researchers and it's up to the breed associations." Carl (R) also noted that the producers he speaks with are often surprised by his honesty in this regard. Additionally, as Shawna (P) noted, many cow/calf operations such as hers involve cross-bred animals for whom the predictive capacities of genomics has not yet been developed. However, she remained optimistic: "once they get that consistency, there's nothing but positives!" Researchers concurred, as Joel (R) noted:

> Because work is focused on a breed by breed basis there isn't a suitable genomics tool available for crossbred cattle. … And we aim to hopefully develop something that could be applicable to cross-bred but right now I really see the genomics for replacement heifers that would be applied in an operation with just Angus cattle.

Researchers did note that cow/calf producers with crossbred cattle could still benefit from the use of genomically enhanced EPDs. At the same time researchers validated the rationality in waiting for more evidence, especially given the cost of accessing genomic information at this time. Given the current limitations of genomics, many producers explained they would indeed wait for evidence in the cattle of early adopters. Upon seeing this evidence most producers claimed they would be more accepting. William (P) spoke to this:

> If it can be demonstrated that it will improve either production or minimise environmental impact or a combination of many things that farmers want, cattlemen won't be quick to embrace it but it will be perceived as positive.

> And, I don't think you'll run into the risk of people challenging whether it's appropriate or not."

Statements such as these may be interpreted as evidence of producers' social trust in scientists.

Some researchers, such as Andre (R) and Joel (R), believed that evidence of genomics being effective was necessary prior to producers fully trusting the science, especially given possible negative past experiences with biotechnologies. Regardless, all researchers interviewed were confident the research being completed was in the best interest of the beef industry. Further, they believed producers are also confident in the ability and intentions of researchers to deliver applicable, useful technology. When it came to researchers protecting their best interests, Andre (R) was certain that producers should and do trust in researchers' ability and intentions. He explained there was no reason not to as their research is publicly funded and therefore done in the public interest. He expressed that his motivations are to give everybody a happier life, to make everybody's life easier. Additionally, perceived producer confidence in research was in part due to collaborations with industry partners. Many researchers made note of the applied nature of their research as a source of assurance that the industry would be on board. For example, Peter (R) stated:

> I'm not doing it for the interest of basic science or research purposes. I'm doing it for the interest that it can be applied for the future and increase production, produce better animals, reduce costs, and make food abundant in the future. So essentially, we always have producers at the mind of why we do research. And we try to look at their scenario while researching to make sure we capture their scenario in our research.

Interviews with producers suggest that overall producers do acknowledge the efforts on the part of researchers to create useful tools. While many producers did not mention researchers explicitly in their predictions of how genomics would come to be used in the industry, those who explicitly did (6/17 participants) were comfortable with scientists' objectives and results. For example, Stephen (P) said, "I think that most of them likely believe that there is some potential value here and they're going about it as scientists should, and that is in the pursuit of truth." Further, William (P) explained he thinks novel

research is valuable, especially when it is balanced with applicable research. Statements such as this exemplify the existence of social trust between science and research institutions. Both participants who did and did not mention scientists prioritised their concerns related to the application of the science rather than the science itself. For these participants, genomics would become part of ongoing struggles with power and agency within the beef industry and therefore trust influences perspective on genomics through many relationships aside from scientists.

Who Will "Call the Shots"?

With regards to the impact of the application of genomics in the industry producer and researcher views began to diverge. Both groups expected purebred associations and breeders to be the first sector interested in genomics and to work with researchers to enhance the applicability of genomics in the industry. In other words, it is widely anticipated that genomics will be supplied initially from breeders and their associations, in collaboration with researchers and corporate labs. However, the perspectives on likely demand for genomics – to select for certain traits or to provide evidence of the presence of certain traits – are more varied.

In general, researchers identified some supply chain related challenges to adoption but maintained that increased education would suffice to convince cow/calf producers to use genomics. Brian (R) explained, similarly to the other researchers, that for genomics to impact the industry cow/calf producers must be willing to adopt. Despite this, many researcher participants noted that cow/calf producers would not necessarily be fully compensated for incorporating genomics into their breeding decisions.

> A commercial cow/calf producer makes a decision and says I'm purchasing this bull. It has really good genomically enhanced breeding values for feed efficiency, growth rate, fertility, etc. etc. So I bring it in and now I produce calves that, for example, are efficient and grow fast. Am I going to be compensated? And the answer is: probably not. (Brian (R))

Researchers noted issues with a lack of communication and compensation flowing through the supply chain, albeit to a lesser extent than producers. Most researchers identified flaws in the current system, including the fact that cow/calf producers would

not be compensated for selecting for traits that the feedlots and packers want. Researchers concurred that, for the most part, cow/calf producers are unlikely to choose to breed for these on their own accord; therefore, as Carl (R) clearly stated, the uses of genomics would be "driven backwards," in other words by the packers and feedlots demanding certain genomic characteristics. However, many researchers spoke optimistically of hypothetical futures in which the beef industry would sort out a way for every sector to benefit from genomics, such as through vertical integration. Additionally, with respect to the use of genomics to breed for increased feed efficiency as a means of methane emissions reductions, most of the researchers interviewed believed financial incentives, such as carbon credit schemes, would be necessary and implemented accordingly to incite any sector to partake. However, Andre (R) summarised the sentiments of most researcher participants in saying each sector ought to be convinced of the multiple benefits of genomics to themselves specifically, aside from any additional benefits to be gained through outside compensation. In this regard, researchers exhibited aspects of the knowledge deficit model. Each researcher identified education about the benefits of the science as the means to increase adoption of genomics. For example, Brian (R) had the following recommendation for cow/calf producers:

> Well, I think, just, educate yourself. Educate yourself would be the one. If you don't understand the technology, you don't understand the benefits, you're going to have a hard time making a decision, right? It's true with anything. The less educated you are, the more mistrustful you are about new things, new technologies. ... So, education is a huge component.

Similarly, Sophie (R) expressed the common concern that the risks associated with genomics would come from individuals using it improperly: "If you don't show people how to use it properly and they use it wrong then yeah, they'll screw up. And that's happened in the past. We just have to make sure people are educated." Thus, despite recognising social challenges related to the application of genomics, researchers spoke of lack of knowledge about the science as the focal risk and primary barrier to adoption. They generally did not associate top-down driven demand for the use of genomics as a risk to cow/calf producers, rather as simply the most likely means of genomics being adopted.

In contrast, producer participants expressed concern about power and agency associated with uses of genomics being imposed "from the top down". Most producer participants expressed concern over their ability to use genomics to select for traits that would benefit their personal operations. The vast majority, with a couple exceptions, had a clear answer for who would be directing the use of genomics: "it will come from the top end, not the bottom end. The feedlot end. For efficiency reasons and profitability reasons" (Philip (P)). Chris (P), one of the few participants currently interested and involved in genomics, explained:

> I think the biggest risk is that, from the primary producer level, if somebody else is going to call the shots about our breeding programmes and we may not have really clear goals on what we're trying to do. If you haven't sat down and thought about it as a cow/calf guy, or wherever you fit, it's going to be a lot of pressure from the feedlot and the packing industry to select for cattle that do certain things well, from their perspective. And those are the things that from my perspective at this end of the chain, that's the stuff that will make me go broke. Right, like if I'm picking for, really rapid growth and certain carcass characteristics but I give up fertility, I'll go broke.

Chris (P) did note it is possible for cow/calf producers to use genomics to place themselves in a more powerful position but that would take a considerable amount of knowledge and effort. Many producers based such concerns on past experiences, either within the beef industry or warning signs from other livestock industries currently more heavily influenced by genomics. Jack (P) expressed the concerns of many producers that genomics could strengthen existing feedlot and packer influence over trait selection:

> See, we were influenced there again by the feeders. When I started in this industry, when I was in 4H, when my steer was finished it was 800 pounds. Right? Now, they're 1400 pounds. You know, weaning weight of a cow was 350 - 400 pounds. Weaning weights now are 600 pounds. But we got this great big, inefficient cow that costs us three times as much to winter so that we could get the feedlot guy the calf that he wanted. But it really hurt the primary producer. Right? And so genomics, you know these guys, they forget about that. You still have got to keep an eye on that.

The concerns Michael (P) expressed built upon the risk of genomics serving feedlot over cow/calf producer interests and spoke again to the reduced agency cow/calf producers would experience should genomics facilitate increased corporate power.

> They're going to sell that off to some big conglomerate and that big conglomerate - this is what happened in the hog business and in the chicken business. The farmers don't - basically, the people who do the packing, who sell the meat, control those industries from top to bottom now because they've just taken control. … And, [meat packing corporation] is a huge, huge packer, I mean they're the biggest packer in the world. That's where it will come eventually. I think we're just helping them corner the market on us. So that, that is the one issue I have with genomics.

Such concerns with corporatisation arose intermittently in conversations with producers with regards to the direction of the industry as a whole and the use of genomics in particular. While Marc (P) quipped, "Is Monsanto doing GMO cows yet?", this type of statement suggests concerns over the distribution of power in accessing the benefits of genomics; in particular Marc's statement reflects concerns regarding corporatisation and the resulting concentration of power in the industry. These risks perceived by cow/calf producers speak to the numerous relationships impacting and impacted by the use of genomics in the beef industry. Producers' willingness to engage with genomics and thereby accept exposure to these risks is influenced by trust in these relationships. Concerns regarding the impacts of genomics on personal agency and ability to act in their own best interest as individuals or as a sector, demonstrate a lack of social trust. This lack of social trust is not in science or research institutions, but rather in the functioning of the beef industry and in the intentions of sectors with conflicting interests in particular.

Producers were acutely aware of the vested interests other sectors held in catering the use of genomics to suit their respective needs. In contrast to researchers, whose vested interest was perceived to align with delivering honest, accurate, reliable science, breeding, feedlot, and packing sectors were seen as solely focused on increased profit. Richard (P) explained:

> [Feedlots] would want to put on a pound of beef as cheap as possible. Right? It boils all down to economics. And I mean if they want it then we have to

> follow it … If all of a sudden our cattle aren't performing in the feedlot, well they're not going to bid on them as much so you're not going to get market price so you know you have a problem. And the purebred breeders will, will get into it, just because their animals should have more value if they are proven to have certain traits that you really want.

This statement identifies a common perception that opportunities exist for sectors on either side of cow/calf producers to make a profit with cow/calf producers being squeezed into compliance. Many cow/calf producers generally did not see other sectors, feedlots and packers in particular, as acting in the public interest or doing what is best for the industry as a whole. Many participants described this behaviour as rational but short sighted. Gerald (P), in describing the behaviour of powerful feedlots and packers, said "They're doing nothing wrong. Except, killing the industry." This position is in keeping with descriptions of high scepticism resulting from the perception of others acting in their own, rather than public, best interest and past negative experiences (Poortinga and Pidgeon, 2003).

Familiarity, Informality, and Interpersonal Trust

Along with the evidence of both social trust and distrust in the context of genomics presented above, we must also consider the "social relationships, networks, and identities from which [trust and credibility] are derived" (Wynne, 1992, p.282). The place of trust in the beef industry generally may impact producers' understanding of genomics and trust relative to the science, its developers, and its application. Therefore, participants spoke at length about the role they saw trust playing in their relationships with other individuals and sectors in the beef industry. It is worth nothing that some participants were highly involved in producer organisations while others had no involvement, often by purposeful choice, but the nuances of these divisions are beyond the scope of this paper. Regardless, all producer participants emphasized the importance of dealing with people with whom they are familiar. Given the topic at hand, many mentioned the importance of relationships with the breeders with whom they do business. Bruce (P), for example, presented a typical conversation between himself and a breeder he would be most comfortable buying from, saying:

> There's a relationship there between you, him, and what you're buying and he's selling. Right there. When you can pick up the phone and tell him, 'you know, do you have any extra bulls around?' 'Yes, I do.' 'Can I come look at them?' 'Sure.' 'When's a good day for you?' 'Any time you want to stop in, stop in.' Okay, good enough.

Likewise, Richard (P) noted that he values knowing individual breeders in person as well as by reputation. He said:

> I guess you have to get to know them personally. And they have to be - if they're in business 10, 15, 20 years - obviously they're doing something right or they're not going to be in business. Like, someone just getting into it, new into the business yeah, you'd be a little shy I guess at first. You know, until they've proven themselves.

Interpersonal trust is thus identified as relevant in business decisions. Participants also felt most comfortable getting advice, no matter the topic, from individuals with whom they were familiar. Justin (P), a relatively young producer, noted that he would get guidance from community members he grew up watching. Leo (P), who frequently brought experts to his land for resource management advice explained, "the people - when I talked about that little advisory, the environmental advisory group - I knew them all before hand. I absolutely trust them. If they recommended something, I'd have to have one heck of a good reason to ignore it." Familiarity, gained through interactions with individuals overtime, stood at the forefront of many producers minds when deciding whom to trust.

Many participants explained that through time they developed relationships with individuals in whom trust was based on track record and shared values. Track record, based on either personal past experiences or reputation, was repeatedly mentioned as an important consideration when deciding whom to trust. Jack (P) explained the basis for his decisions of whom to buy bulls from:

> Past experiences or referrals from a mentor or from a person from [the breed] organisations that's dealt with them. There's nothing truer than you know, good news travels slow, bad news travels fast. If the seedstock producer isn't

> honest and forthright word soon gets around and he's having trouble selling his bulls, eh?

Many participants judge a person's track record on a willingness to be open and honest about their actions and the good or bad results. Leo explained

> Mistakes happen. And it's not that, to never make a mistake. You're not judged by never making a mistake. I think I judge people by what you do about it. How you rectify it. Because we're all going to make mistakes. And if you screw up, you just own up to it and say, I screwed up, here's where I went wrong, and here's what I'm going to do about it. Then we're good to go. Or if you're like some politicians, 'I've never made a mistake in my life', you say buzz off.

The shared values that accompany this type of behaviour – honesty, transparency, openness, integrity - were listed as essential to trustworthiness by the participants in this study. These shared values were also associated with perceived shared goals. Henry clearly articulated the sentiments of most participants in saying "I trust like-minded people. People who I think are like-minded to me." In this vein, the majority of producers, such as Thomas, indicated a desire for individuals to approach issues with the mindset "what is good for the industry will be good for me" rather than vice versa. These types of sentiments are associated with general trust (Poortinga & Pidgeon, 2003) as well as with salient value similarity, albeit with an interpersonal focus (Poortinga & Pidgeon, 2003; Siegrist *et al.*, 2000).

Typically, participants explained that relationships with individuals shaped their perceptions of organisations, rather than vice versa. When asked about his trust in organisations, Chris's (P) description of this phenomenon was exemplar:

> In the work we've done with [Government of Alberta department] the people who have been involved are fantastic. The work they've done is fantastic. Their hearts, and their minds, and their approach are definitely in the right place. Do I trust the department […]? Not as far as I could throw them. Right? So, sometimes the mandate behind particularly a governmental organisation is not necessarily pure and clear. Although, most times the

> people doing the work and interested in it have the greatest personal motives they could ever have.

Many participants echoed this sentiment, generally stating that it is the individuals who make up organisations. Where social trust was lacking, particularly with respect to government, positive relationships with individuals and the presence of interpersonal trust facilitated continued interactions with an organisation or institution. Repeatedly, participants spoke of a dislike for regulation and a distrust of government overall but noted positive experiences with government employees willing to go out on a limb to do what's best for the industry to the extent they are able. Similarly, both producers heavily involved with industry organisations and producers with significant disdain for them, looked most kindly upon experiences with individuals from producer organisations rather than the organisations themselves. In the end, many participants agreed with Shawna's (P) statement: "The organisations can only go so far, making sure that the science is correct, making sure that the process of gathering information is correct, but the actual transactions have to be left up to the individuals." As discussed further below, the practice of developing trust through interpersonal relationships rather than with organisations comes to influence producers' perceptions of genomics and willingness to adopt. Many organisations such as purebred associations, research groups, and government departments are involved with genomic research and would like to encourage the adoption. However, these organisations cannot rely on producers' social trust alone to garner support for genomics and therefore ought to acknowledge traditions of interpersonal trust.

Many participants cited the continued presence of informal business dealings as evidence for the prominence of interpersonal trust in the beef industry. Many described their ability to do business as tied intimately to familiarity and interpersonal trust. Trust in individuals allowed for participants to feel comfortable in informal exchanges of significant amounts of money or cattle. Marc (P) spoke to the importance of these interactions to the industry: "In the ranching business, I think, so much in the ranching business is been built on integrity through the last 150 years has been built on integrity and handshakes and cash deals." For many this was a source of pride. William (P) explained:

> In farming and in the cattle business particularly, we can rely on trust to a very high degree. I'm thinking particularly in terms of business dealings. We, we trade huge numbers of cattle, buying and selling and that, over phone calls. Without signed contracts. And, virtually always works out. So within our industry there's a huge amount of trust.

Informal business relationships were largely built on interpersonal relationships embedded within industry culture. However, as Stephen (P) noted, institutional structures allow producers to rest assured their interests will be protected should interpersonal trust be misplaced; in his perspective Canada has a "strong rule of law" and "freedom to operate" that facilitate predictable business interactions. The prominence of informal deals in the industry may be considered an example of the success of intersecting interpersonal and social trust. Further, participants' appreciation of informality within the beef industry exemplifies the type of role they would like trust to play.

Participants in this study suggest the tradition of relying on interpersonal relationships for advice, resources, and business interactions permeates how producers come to view genomics. For individuals actively involved with genomics, interpersonal relationships with individuals promoting or developing genomics for the industry were integral to their decision to be involved. Thomas (P) attributed his own and involvement with genomics to relationships with particular, individual scientists and trusted members of an organisation involved with genomics, saying, "we'd had a longstanding history with the start up scientists." He explained further:

> Had we as a company and I as an individual not had a lot of trust in researchers like [named individuals], all of those researchers that we had developed relationships with, if we didn't have that level of trust there are some of those things we would have never ever tried.

Similarly, participants who were not involved with genomics frequently identified more knowledgeable or involved individuals on whom they would rely for guidance. Leo (P) explained that when presented with an opportunity to use genomics he would confer with a longstanding friend:

> I wouldn't be qualified to understand the legitimacy of what they're doing. Not that I wouldn't trust them, it's just that I'd be out of my league. So that's

> why I'd go back to the guys I know. [I'd say] 'So [friend], what do you think of this hare-brained idea?!' And he'd say, 'I know that researcher and he's great and I think he's really on the right track'.

On this note, others, such as Warren (P), shared stories of people they admire who also use genomics and suggested they would consider modeling their behaviour after these individuals. Henry (P) currently had limited interest in genomics but explained that with time he would come to develop relationships with individuals involved. He stated, "I'm going to pay attention to the industry and *those players will point themselves out and be members of my inner circle* for consulting on that but at this minute in time, no, I don't have anybody" (emphasis added). Participants' perspectives on trust in this regard emphasize the continued importance of interpersonal trust with respect to the application of science and technology in their lives.

Discussion

The role of trust in public understanding and acceptance of science has been theorised and researched at length, maintaining a focus largely on the importance of social trust. This focus on social trust is fueled by a perceived lack of face-to-face interaction with those involved with science and technology. Therefore, the public's trust relative to science and technology is assumed to be placed or not placed in organisations and institutions to develop, manage, and regulate science and associated risks (Roberts *et al.*, 2011). To engage with this literature, this research presents discussions with cow/calf producers, as well as genomics researchers, about the place of genomics in the beef industry and the impact of trust on perceptions of genomics and willingness to adopt. This study identifies the need to consider the degree to which social trust is or is not established with several entities and how perceived implications of using the science impact and are impacted by these distributions of social trust. Furthermore, the importance of interpersonal trust in this context gives pause to reflect on the continued importance of familiarity and individual relationships, despite the institutional nature of scientific knowledge creation and dissemination across the beef sector in Alberta.

Multiple Social Trusts

Social trust, as noted above, is defined as "the public's willingness to be vulnerable to the actions of the designers, creators, and operators of science on the expectation that they will behave in a way beneficial to the public" (Roberts *et al.*, 2011, p.625) or "the willingness to rely on those who have the responsibility for making decisions and taking actions related to the management of technology, the environment, medicine, or other realms of public health and safety" (Siegrist *et al.,* 2000, p.354). Social trust is deemed necessary to cope with the complexities of modern societies and widespread exposure to new technologies and associated potential risks (Luhmann, 1979; Roberts *et al.*, 2011; Siegrist *et al.*, 2000). However, as the definitions above suggest, there are multiple entities to which social trust may or may not be afforded in ways that impact public acceptance of technology. This research emphasizes this relational aspect of the implications of social trust.

Much of the public understanding of science or risk perception research focuses on two groups in which social trust is considered relevant: government and scientists. Trust in government is often considered to be of paramount importance to public acceptance of risk and exposure to risk (Poortinga & Pidgeon, 2006; Siegrist & Cvetkovich, 2000; Siegrist *et al.*, 2000). Frequently, trust in government is most closely associated with trust in risk regulation, wherein high trust in government results in high trust in risk regulation and subsequently high acceptance of a technology or expose to risk (Poortinga & Pidgeon, 2006). In this case, producers exhibited a general distaste for government, largely linked to a strong distaste for regulation. Many producers did not mention government as a factor in the application of genomics in the industry. Those who did mention government most often considered it as a funding body or a means of information dissemination. Minimal mention of government by participants suggests that other social and interpersonal relationships are more significant to producers' perceptions and adoption of genomics. The role of the government, however, was not explored at length with the research participants. More significant attention was paid to trust in the science and those developing it. Trust in scientists rather than a lack of scientific literacy, is often considered the primary barrier to the acceptance of science (Roberts *et al.*, 2011;

Wynne 1992). However, the knowledge deficit model still permeates experts' opinions of lay perceptions. It was therefore unsurprising that many researchers who participated in this study maintained that educating producers would alleviate concerns and foster adoption. The researchers interviewed perceived high levels of trust from producers with respect to scientists' abilities and intentions to create safe, reliable tools and therefore understand trust as a less significant a barrier than knowledge gaps among the producers. Interestingly, most producer participants did in fact exhibit the social trust in science and scientists that the researchers anticipated. Further, the benefits and concerns associated with the science of genomics listed by producer participants were fairly congruent with the benefits and concerns listed by researchers. This research outcome contrasts with literature citing a crisis of legitimacy in publics' perceptions of science as a barrier to adoption of science and technology (Roberts *et al.*, 2011). While the importance of trust in scientists and knowledge are not negated, these findings do suggest there is more to consider. Specifically, attention ought to focus on trust in those with a role in the social impacts from genomics.

When trust in scientists exists, producers' concerns seem to shift from "will the science behave as projected, in ways that are positive at the genetic level" to "when the science does as projected, what will this mean for me on an individual and social level". This introduces a plethora of individual and social agents in whom trust is potentially relevant. Producers in this case saw the other sectors in the industry as impacting the degree to which genomics can benefit those at the cow/calf level. In regards to other sectors, feedlots and packers in particular, skepticism emerged as particularly strong. Poortinga and Pidgeon (2003) explain skepticism is made up of vested interest and accountability factors. Accordingly, the findings of this study speak most directly to the vested interest aspect of skepticism. Producer participants foresaw other sectors using their positions of power to cater the use of genomics throughout the industry to their particular needs. Specifically, each sector has a vested interest in traits that will maximise their own profit. Researchers suggested that through multi-trait selections cattle could be bred with each of the traits the various sectors desire. However, many cow/calf producers did not trust the structures of the beef industry to enable all needs to be met. Many participants exhibited high degrees of skepticism due to perceived likelihood that the

vested interests of the feedlot and packing sectors would be prioritized. Considered holistically, these findings suggest that the relationship between social trust and acceptance of science and technology is greater than simply trust in the science; rather, the influence of social trust on perceptions of the application of the science within social structures and subsequent impacts on personal agency and ability to benefit ought to be considered. It becomes evident that trust in various social actors can be influential from the awareness through full adoption stages of the diffusion of innovation (Rogers, 1967). That producers' express concerns not only with the science but also its application is further evidence that potential adopters of an innovation do engage purposefully and creatively, considering multiple risks and benefits (Greenhalgh *et al.*, 2004). Overall, we are reminded that scientists' intentions and abilities to objectively develop safe technologies do not make technologies immune to uses that privilege some actors and intentions over others (Herring, 2007).

Interpersonal Influence

"Trust is huge!" or similar statements often began producer participants' comments about the role of trust in the beef industry and in their business or environmental management decisions. When pushed to say more, producers began to speak about the people they know - their mentors and role models, their peers, and regular buyers and sellers. Further, individuals' reputations, track records, values, and character were consistently identified as qualities with which one could become familiar and subsequently trust. This familiarity, however, make take many years to establish. Wynne (1992) suggests that the social relationships and identities influencing the uptake of knowledge and judgments of credibility and trust are evolving. The importance producers place in allowing trust to develop over time reflects the idea of trust as evolving. Further, the roles of interpersonal trust described herein suggest interpersonal trust may catalyse and enable evolution in both social relationships and perceptions of science and technology. In part this is evident by willingness to engage with organisations in which they have little social trust because of high levels of interpersonal trust with individual members or employees. Additionally, with regards to genomics specifically, participants expressed that familiar, trustworthy individuals would be most

influential in their decisions to adopt or not. In this sense, interpersonal trust can be considered integral to producer' moving from one stage of the diffusion and adoption of innovation to the next, possibly with different interpersonal relationships having influence at each stage (Rogers, 1976). Overall, the participants in this study value interpersonal trust and the benefits it brings, such as informality in the industry, thus giving interpersonal trust potential as an agent for change. This perspective on interpersonal trust conflicts with claims in the public understanding of science literature. Some suggest there is a limited role for interpersonal trust given the institutional nature of scientific research and development (Roberts *et al.*, 2011). Others identify negative consequences of interpersonal trust based on familiarity insofar as it reduces critical engagement (Parkins, 2010). With respect to the former, it is possible that the 'traditional' or 'old fashioned' nature of the beef industry, as identified by both cow/calf producer and researcher participants, re-introduces personal relationships into the interactions between technologies and lived experiences. However, it is worth considering that interpersonal trust may have a greater role in general public understanding of science than previously thought. With respect to the latter, we are called to consider the role of both social/institutional and interpersonal trust and the variety of contexts in which one or the other may enable critically engaged dialogue pertaining to acceptance of expert science. In this context, it is possible cow/calf producers may become withdrawn from dialogue pertaining to the role of genomics in the beef industry due to perceived powerlessness. Familiarity or interpersonal trust with individuals who are involved may serve as an invitation to participate. However, as many researchers interviewed for this study would concur, uncritical or under-informed adoption of genomics based on the positive experiences of a familiar individual could have negative consequences.

If in fact critical trust, resulting from high general trust and high skepticism, is socially optimal (as is suggested by Poortinga & Pidgeon (2003)), we would be remiss to focus solely on social trust and ignore the contributions of interpersonal trust. The results of this study suggest that cow/calf producers' willingness to engage with genomics, despite high levels of skepticism in regards to the vested interests of other sectors, is highly influenced by interpersonal relationships that could be said to increase their

general trust. It is interesting to consider the interactions between social and interpersonal trust in this case where high social trust in scientists, high interpersonal trust in longstanding peers, and high skepticism (or low social trust) in other industry sectors culminate in participants' perception of genomics and how they stand to benefit from the technology. Those seeking to foster increased acceptance of science and technology, such as promoters of genomics in the beef industry, may benefit from considering the context-specific ways interpersonal and social trust interact to enable critical social trust.

Conclusion

As part of a broader discussion regarding the diffusion of innovation within agriculture, this chapter seeks to understand the role of trust in the adoption and application of genomics in the beef industry. The perspectives of both cow/calf producers and genomics researchers inform this chapter. In comparing both groups' ideas about genomics and its role in the beef industry, nuances of trust are identified. Perspectives converge on the use of genomics as a tool for increased accuracy in breeding decisions and producers exhibit social trust in the intentions and abilities of scientists to deliver reliable technology. In contrast, producers expressed low social trust and high skepticism relative to the other sectors in the beef industry. Many participants were concerned feedlots and packers would control uses of genomics and in doing so limit the agency of cow/calf producers to select for traits most beneficial to their own operations. In addition to implications of social trust, as were anticipated through the literature, producer participants highlighted the importance of interpersonal trust. Familiarity with other individuals, be they other cow/calf producers or members of other sectors with whom business takes place, allowed for trust to grow over time and perpetuate the well-liked tradition of informality within the beef industry. This purpose for interpersonal trust extended to influence producers' engagement with genomics. The involvement of trusted individuals was cited as a significant factor in one's own willingness to adopt despite lack of social trust. In addition to gaining insight into the various roles for trust in producers' perceptions of a specific technology, this chapter stands as an example of the influence of trust in the diffusion of innovation.

This research involved experts in the field of genomics and experts in the field of cow/calf operations and is thus distinct from and complementary to research that addresses differences in expert and lay public perceptions. These findings encourage future research in the realm of public understanding of science, risk perception, and trust to consider both the multiplicities of social trust that may be influential on individuals' perceptions of science and its application as well as the influence of interpersonal trust. In practice, those interested in encouraging the use of genomics in the beef industry, particularly adoption by cow/calf producers, ought to be aware of the social implications of technology adoption and consider avenues for addressing related concerns.

References

Arnott, D. (2007). Trust – current thinking and future research. *European Journal of Marketing*, *41*(9/10), 981-987.

Arvai, J. (2014). Comment: The end of risk communication as we know it. *Journal of Risk Research,* DOI: 10.1080/13669877.2014.919519

Bell, M., Wall, E., Russell, G., Simm, G., & Stott, A.W. (2011). The effect of improving cow productivity, fertility, and longevity on the global warming potential of dairy systems. *Journal of Dairy Science*, *94*, 3662-3678.

Bickerstaff, K., Pidgeon, N., Lorenzoni, I., & Jones, M. (2010). Locating scientific citizenship: The institutional contexts and cultures of public engagement. *Science, Technology & Human Values, 35*(4), 474-500.

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*, *10*(2), 141-163.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Critchley, C. R. (2008). Public opinion and trust in scientists: The role of the research context, and the perceived motivation of stem cell researchers. *Public Understanding of Science*, *17*(3), 309-327.

de Haas, Y., Windig, J.J., Calus, P.L., Dijkstra, J., de Haas, M., Bannink, A., and Veerkamp, R.F. (2011). Genetic parameters for predicting methane production and potential for reducing enteric emissions through genomic selection. *Journal of Dairy Science 94*, 6122-6134.

Earle, T. C. (2010). Trust in risk management: A model- based review of empirical research. *Risk Analysis*, *30*(4), 541-574.

Eshel, G., Shepon, A., Makov, T., & Milo, R. (2014). Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *Proceedings of the National Academy of Sciences*, doi:10.1073/pnas.1402183111

Fischhoff, B., Slovic, P., & Lichtenstein, S. (1982). Lay foibles and expert fables in judgments about risk. *The American Statistician*, *36*(3b), 240-255.

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Quarterly*, *82*(4), 581-629.

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.

Herring, R. J. (2007). Political ecology from landscapes to genomes: science and interests. *The SAGE Handbook of Environment and Society*, 299.

Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food policy*, *32*(1), 25-48.

Luhmann, N. (1979). *Trust and Power: Two Works by Niklas Luhmann*. Chichester: Wiley.

Paarlberg, R. (2010). *Food politics: What Everyone Needs to Know*. New York, NY: Oxford University Press.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Animal Production Science*, *46*(11), 1407-1424.

Parkins, J. R. (2010). The problem with trust: Insights from advisory committees in the forest sector of Alberta. *Society and Natural Resources*, *23*(9), 822-836.

Poortinga, W., & Pidgeon, N. F. (2003). Exploring the dimensionality of trust in risk regulation. *Risk Analysis*, *23*(5), 961-972.

Poortinga, W., & Pidgeon, N. F. (2006). Prior attitudes, salient value similarity, and dimensionality: Toward an integrative model of trust in risk regulation. *Journal of Applied Social Psychology*, *36*(7), 1674-1700.

Prokopy, L. S., Floress, K., Klotthor-Weinkauf, D., & Baumgart-Getz, A. (2008). Determinants of agricultural best management practice adoption: Evidence from the literature. *Journal of Soil and Water Conservation*, *63*(5), 300-311.

Roberts, M. R., Reid, G., Schroeder, M., & Norris, S. P. (2013). Causal or spurious? The relationship of knowledge and attitudes to trust in science and technology. *Public Understanding of Science*, *22*(5), 624-641.

Rogers, E. (1962). *Diffusion of Innovations.* New York, NY: The Free Press.

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.

Siegrist, M., & Cvetkovich, G. (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis*, *20*(5), 713-720.

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

Sztompka, P. (1999). *Trust: A Sociological Theory*. Cambridge, MA: Cambridge University Press.

van den Heuvel, T., van Trijp, H., Gremmen, B., Jan Renes, R., & van Woerkum, C. (2006). Why preferences change: Beliefs become more salient through provided (genomics) information. *Appetite*, *47*(3), 343-351.

Vanclay, F. (2004). Social principles for agricultural extension to assist in the promotion of natural resource management. *Animal Production Science*, *44*(3), 213-222.

Wynne, B. (1992). Misunderstood misunderstanding: Social identities and public uptake of science. *Public Understanding of Science*, *1*(3), 281-304.

Chapter 4 – Conclusion

Throughout this research I sought to make sense of some of the complexities of the environmental impacts of beef production. I explored cow/calf producers' relationships with the environment, with their own self-perceptions, with genomic science, and with others in the industry. While the substantive chapters of this thesis engage with different literature and focal topics, both chapters provide insight into opportunities and challenges for environmental management. Further, considering the papers together reinforces the importance of familiarity in producers' experiences with the environment and environmental management.

Chapter 2 explores the tension between producers' sense of stewardship and the negative environmental impacts of the industry and suggests that the familiar helps to create space for these competing, yet legitimate, claims to co-exist. In this sense, the familiar is that which producers have come to know, either physically, with respect to the land, or personally, through interpersonal relationships over time. While drawing from the familiar equips producers with a sense of pride in their own environmentalism this tendency also facilitates a continued disconnect between producers and the less immediate environmental impacts of the beef production system as a whole. Participants' fragmented discourses of sustainability are reified through their material experiences. Thus, while the familiar can encourage the protection of local environmental features it fails to incorporate cumulative effects into producers' conceptualisations of environmental stewardship and environmental sustainability. The theme of familiarity is also important in Chapter 3. Chapter 3 focuses more specifically on the role of trust in producers' perceptions and adoption of genomics and notes how familiar relationships that foster interpersonal trust are highly influential. Again, the strong role of the familiar may have mixed consequences. On a positive note, interpersonal trust may contribute producers' willingness to consider the benefits of using genomics while at the same time being critically aware and questioning of possible negative impacts. In contrast, heavy reliance on familiar individuals and interpersonal trust may create challenges. For example, relying solely on the familiar may be a barrier to innovation for individuals with

limited contact with persons involved with the new idea or practice. It is also interesting to consider how individuals' behaviours may be constrained, in positive or negative ways, for fear of disrupting interpersonal trust and facing sanctions. Future research could inquire into how individuals' technology adoption practices are impacted by the desire to become or remain a trusted member of the community. Overall, the understanding that producers, and other groups, draw heavily upon the familiar in making decisions regarding the environment and related practices has implications for environmental management and technology adoption. For example, the familiar could be incorporated into issue framing to encourage engagement and participation. Further research could also identify means of overcoming the barriers to environmental sustainability associated with focusing on the familiar.

The topic of genomics is explored throughout this thesis and is both informed by and builds upon the theories applied herein. Producers' and researchers' perspectives on genomics are critically analysed using sociological theory to inform practical considerations. Drawing from sustainable development and materiality theories I identify opportunities and risks related to genomics. I find that producers see the appeal in selectively breeding for increased feed efficiency for local environmental purposes; therefore it seems genomics, while facilitating environmental impact reduction at both local and global scales, does not challenge the disconnect between producers and systemic environmental harms. Future research in this line should consider how genomics could operate as part of one of many strategies to address environmental degradation from the beef production system. For example, while this research suggests genomics simply does not challenge the status quo, it is important to further understand if or how the use of a technology such as genomics stands as a barrier to collective, system-wide change. Through the public understanding of science and trust literature I am able to suggest producers' social trust in science is not the barrier to adoption that some might expect. Rather, low social trust in other industry sectors, such as feedlots and packers, is evident and reflects the need for cow/calf producers' concerns with the social impact of applying genomics to be addressed. While interpersonal trust may facilitate producers' engagement, concerns related to the beef industry system overall perpetuate high degrees of skepticism. Additional research could focus on the potential social impacts of the

application of genomics in the industry and ways of mitigating concerns.

The use of genomics for pro-environmental purposes in the beef industry also serves as a unique context in which to critically examine and build upon existing theoretical perspectives. Producers' narratives of their relationship to the environment, their interest in using genomics for feed efficiency, and their general disinterest in mitigating contributions to climate change elucidate a cycle of sustainable development narratives influencing experiences on the land and in turn material experiences influencing conceptualisations of sustainability. This suggests future theorisation and research ought to consider the influence of the material and familiar in sustainable development and the associated implications for achieving environmental sustainability. The use of genomics also creates an opportunity to consider public understanding of science and the role of trust in a new light. I compare and contrast expert genomics researchers' perspectives with those of producers who are experts in their own right, rather than with the perspectives of lay publics. In doing so I re-introduce a role for interpersonal trust in facilitating critical trust and draw attention to multiple social trusts in not only science and government, but also in other actors in the beef industry. Focusing on producers, as informed and complex potential adopters, further informs the diffusion of innovation literature by suggesting trust is influential in transitioning from one stage to another. Additional theory and research in this regard should remain cognizant of a role for interpersonal trust in public understanding of science and should consider concerns with the social, rather than only the technical, impacts of science.

This research is also encouraging of continued application of a social constructionist approach to understanding issues related to environmental behaviours perspectives on sustainability, and understandings of science in agricultural and other contexts. I aimed to socially situate producers' perceptions of the environment and genomics. Doing so created an opportunity to explore how producers perceive their environments and the social construction of the meanings producers attach to features of the environment, their identities, relationships, values, and practices. It is my hope that future research from this perspective will contribute to our understanding of environmental impacts and enhance environmental sustainability, in the beef industry and elsewhere.

References

Alberta Cattle Feeders Association. (2014). *Beef Production in Alberta*. Retrieved from http://www.cattlefeeders.ca/industry/production.aspx April 25, 2014

Arnott, D. (2007). Trust – current thinking and future research. *European Journal of Marketing*, *41*(9/10), 981-987.

Arvai, J. (2014). Comment: The end of risk communication as we know it. *Journal of Risk Research,* DOI: 10.1080/13669877.2014.919519

Banerjee, S. B. (2003). Who sustains whose development? Sustainable development and the reinvention of nature. *Organization studies*, *24*(1), 143-180.

Beauchemin, K. A., Janzen, H., Little, S. M., McAllister, T. A., & McGinn, S. M. (2010). Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. *Agricultural Systems*, *103*(6), 371-379.

Bell, M., Wall, E., Russell, G., Simm, G., & Stott, A.W. (2011). The effect of improving cow productivity, fertility, and longevity on the global warming potential of dairy systems. *Journal of Dairy Science*, *94*, 3662-3678.

Bickerstaff, K., Pidgeon, N., Lorenzoni, I., & Jones, M. (2010). Locating scientific citizenship: The institutional contexts and cultures of public engagement. *Science, Technology & Human Values, 35*(4), 474-500.

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*, *10*(2), 141-163.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Burr, V. (2003). *Social Constructionism*. Psychology Press.

Burton, R. J. (2004). Seeing through the 'good farmer's' eyes: towards developing an understanding of the social symbolic value of 'productivist' behaviour. *Sociologia Ruralis*, *44*(2), 195-215.

Burton, R., Kuczera, C., & Schwarz, G. (2008). Exploring farmers' cultural resistance to voluntary agri- environmental schemes. *Sociologia Ruralis*, *48*(1), 16-37.

Canadian Cattle Genome Project. (2012). Science. Retrieved from http://www.canadacow.ca/project/science

Carolan, M. S. (2006). Do you see what I see? Examining the epistemic barriers to sustainable agriculture. *Rural Sociology*, *71*(2), 232-260.

Carolan, M. S. (2008). More- than- representational knowledge/s of the countryside: How we think as bodies. *Sociologia Ruralis*, *48*(4), 408-422.

Creswell, J. (2013). Five qualitative approaches to inquiry. *Qualitative Inquiry & Research Design: Choosing Among Five Approaches.* Los Angeles: SAGE.

Critchley, C. R. (2008). Public opinion and trust in scientists: the role of the research context, and the perceived motivation of stem cell researchers. *Public Understanding of Science*, *17*(3), 309-327.

Daly, K.J. (2007). Epistemological considerations in qualitative research. *Qualitative Methods for Family Studies & Human Development*. Ed. K.Daly. Thousand Oaks: Sage. pp.19-27.

de Haas, Y., Windig, J.J., Calus, P.L., Dijkstra, J., de Haas, M., Bannink, A., and Veerkamp, R.F. 2011. Genetic parameters for predicting methane production and potential for reducing enteric emissions through genomic selection. *Journal of Dairy Science 94*, 6122-6134.

De Schutter, O. (2014). *Report of the Special Rapporteur on the right to food, Olivier De Schutter, Final Report: The Transformative Potential of the Right to Food.* United Nations General Assembly.

Dobson, A. (1996). Environment sustainabilities: An analysis and a typology. *Environmental Politics*, *5*(3), 401-428.

Earle, T. C. (2010). Trust in risk management: A model- based review of empirical research. *Risk Analysis*, *30*(4), 541-574.

Ellis, C. (2013). The symbiotic ideology: Stewardship, husbandry, and dominion in beef production. *Rural Sociology*, *78*(4), 429-449.

Eshel, G., Shepon, A., Makov, T., & Milo, R. (2014). Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *Proceedings of the National Academy of Sciences*, *111*(33), 11996-12001.

Fischhoff, B., Slovic, P., & Lichtenstein, S. (1982). Lay foibles and expert fables in judgments about risk. *The American Statistician*, *36*(3b), 240-255.

Freudenburg, W. R. (2005). Privileged access, privileged accounts: Toward a socially structured theory of resources and discourses. *Social Forces*, *84*(1), 89-114.

Freudenburg, W. R., Frickel, S., & Gramling, R. (1995). Beyond the nature/society divide: Learning to think about a mountain. *Sociological Forum 10*(3), 361-392

Garnett, T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers. *Environmental Science & Policy*, *12*(4), 491-503.

Genome Canada. (2014). Welcome to Genome Canada's GE3LS Page. Retrieved from http://www.genomecanada.ca/en/ge3ls/

Goldman, M., & A. Schurman, R. (2000). Closing the "great divide": New social theory on society and nature. *Annual Review of Sociology*, *26*(1), 563-584.

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Quarterly*, *82*(4), 581-629.

Greider, T., & Garkovich, L. (1994). Landscapes: The social construction of nature and the environment. *Rural Sociology*, *59*(1), 1-24.

Greider, T., & Little, R. L. (1988). Social action and social impacts: Subjective interpretation of environmental change. *Society & Natural Resources*, *1*(1), 45-55.

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.

Heller, M. C., Keoleian, G. A., & Willett, W. C. (2013). Toward a life cycle-based, diet-level framework for food environmental impact and nutritional quality assessment: A critical review. *Environmental Science & Technology*, *47*(22), 12632-12647.

Herring, R. J. (2007). Political ecology from landscapes to genomes: Science and interests. *The SAGE Handbook of Environment and Society*, 299.

Horlings, L. G., & Marsden, T. K. (2011). Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'. *Global Environmental Change*, *21*(2), 441-452.

Imran, S., Alam, K., & Beaumont, N. (2011). Reinterpreting the definition of sustainable development for a more ecocentric reorientation. *Sustainable Development*.

Knoblauch, H. (2005). Focused ethnography. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, *6*(3).

Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food policy*, *32*(1), 25-48.

Lang, T., & Barling, D. (2013). Nutrition and sustainability: An emerging food policy discourse. *Proceedings of the Nutrition Society*, *72*(01), 1-12.

Lele, S. M. (1991). Sustainable development: A critical review. *World Development*, *19*(6), 607-621.

Luhmann, N. (1979). *Trust and Power: Two Works by Niklas Luhmann*. Chichester: Wiley.

Luke, T. W. (2005). Neither sustainable nor development: Reconsidering sustainability in development. *Sustainable Development*, *13*(4), 228-238.

Marshall, C. & Rossman, G.B. (2011). Qualitative research genres. In C. Marshall & G.B. Rossman (Eds.) *Designing Qualitative Research*, Los Angeles: SAGE.

McAlpine, C. A., Etter, A., Fearnside, P. M., Seabrook, L., & Laurance, W. F. (2009). Increasing world consumption of beef as a driver of regional and global change: A call for policy action based on evidence from Queensland (Australia), Colombia and Brazil. *Global Environmental Change*, *19*(1), 21-33.

McGuire, J., Morton, L. W., & Cast, A. D. (2013). Reconstructing the good farmer identity: Shifts in farmer identities and farm management practices to improve water quality. *Agriculture and Human Values*, *30*(1), 57-69.

Mebratu, D. (1998). Sustainability and sustainable development: Historical and conceptual review. *Environmental Impact Assessment Review*, *18*(6), 493-520.

Nguyen, T. T., Hermansen, J.E., & Mogensen, L. (2010). Environmental consequences of different beef production systems in the EU. *Journal of Cleaner Production, 18*, 756-766.

O'Riordan, T., & Voisey, H. (1997). The political economy of sustainable development. *Environmental Politics*, *6*(1), 1-23.

Paarlberg, R. (2010). *Food Politics: What Everyone Needs to Know*. New York, NY: Oxford University Press.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Animal Production Science*, *46*(11), 1407-1424.

Park, J. R., McFarlane, I., Hartley Phipps, R., & Ceddia, G. (2011). The role of transgenic crops in sustainable development. *Plant Biotechnology Journal*, *9*(1), 2-21.

Parkins, J. R. (2010). The problem with trust: Insights from advisory committees in the forest sector of Alberta. *Society and Natural Resources*, *23*(9), 822-836.

Poortinga, W., & Pidgeon, N. F. (2003). Exploring the dimensionality of trust in risk regulation. *Risk Analysis*, *23*(5), 961-972.

Poortinga, W., & Pidgeon, N. F. (2006). Prior attitudes, salient value similarity, and dimensionality: Toward an integrative model of trust in risk regulation. *Journal of Applied Social Psychology*, *36*(7), 1674-1700.

Prokopy, L. S., Floress, K., Klotthor-Weinkauf, D., & Baumgart-Getz, A. (2008). Determinants of agricultural best management practice adoption: Evidence from the literature. *Journal of Soil and Water Conservation*, *63*(5), 300-311.

Redclift, M. (2005). Sustainable development (1987–2005): an oxymoron comes of age. *Sustainable Development*, *13*(4), 212-227.

Roberts, M. R., Reid, G., Schroeder, M., & Norris, S. P. (2013). Causal or spurious? The relationship of knowledge and attitudes to trust in science and technology. *Public Understanding of Science*, *22*(5), 624-641.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological economics*, *48*(4), 369-384.

Rogers, E. (1962). *Diffusion of Innovations.* New York, NY: The Free Press

Seghezzo, L. (2009). The five dimensions of sustainability. *Environmental Politics*, *18*(4), 539-556.

Shiva, V. (2000). *Stolen Harvest: The Hijacking of the Global Food Supply*. Cambridge, MA: South End Press.

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.

Siegrist, M., & Cvetkovich, G. (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis*, *20*(5), 713-720.

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

Silvasti, T. (2003). The cultural model of "the good farmer" and the environmental question in Finland. *Agriculture and human values*, *20*(2), 143-150.

Statistics Canada. (2014). Table 003-0032 Number of cattle, by class and farm type. *CANSIM*. Retrieved from http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=0030032&tabMode=dataTable&srchLan=-1&p1=-1&p2=9

Sztompka, P. (1999). *Trust: A Sociological Theory*. Cambridge, MA: Cambridge University Press.

Tan, M., Tan, R., & Khoo, H. (2012). Prospects of carbon labeling – a life cycle point of view. *Journal of Cleaner Production*, *72*, 76-88.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research & Applications*, *5*, 147-158.

Urry, J. (2000). Mobile sociology. *The British Journal of Sociology*, *51*(1), 185-203.

van den Heuvel, T., van Trijp, H., Gremmen, B., Jan Renes, R., & van Woerkum, C. (2006). Why preferences change: Beliefs become more salient through provided (genomics) information. *Appetite*, *47*(3), 343-351.

Vanclay, F. (2004). Social principles for agricultural extension to assist in the promotion of natural resource management. *Animal Production Science*, *44*(3), 213-222.

Wynne, B. (1992). Misunderstood misunderstanding: Social identities and public uptake of science. *Public Understanding of Science*, *1*(3), 281-304.

Appendix A - Interview Guide: Cow/calf Producer Interviews

General Environmental Impacts

1) I'd like to start out by hearing a bit about your involvement with beef production –
    a. Can you tell me a bit about your current cow calf operation – how long you've had it, how large it is?
    b. Are you involved with the beef industry in other ways (active in organisations, other types of operations or businesses, etc).
        i. Presently
        ii. In the past

2) Next, I'd like to chat a bit about how you see beef production generally and your farm fitting in with natural environment.
    a. Where do you think the industry is in harmony with or is beneficial to the environment? To start, where do you think environmental impacts from beef production overall occur?
    b. Do you see impacts to climate change occurring from beef production? If so, where?

3) Now more specifically, what environmental impacts, good or bad, are possible on your farm?
    - soil, water, biodiversity, climate change, etc.

4) What sort of responsibility to you feel towards the natural environment when it comes to your farm practices?
    a. Can you tell me about any best management practices that you employ?

Decision Making

1) When it comes to making decisions about on-farm practices that can impact the environment, who makes those decisions on your farm? If you -
    a. Who do you discuss these decisions with?
    b. Do you seek out information about these practices? If so, from where/whom?

2) Are there certain individuals that you find are able to sway your ideas around management decisions that impact the environment?
    a. What are the characteristics you like about this/these individual(s)?
    b. Does trust play a role?

3) Are there certain organisations that you find are able to sway your ideas around management decisions that impact the environment?
    a. What are the characteristics you like about these/this group(s)?
    b. Does trust play a role?

4) Can you walk me through the though process you go through when presented with an option for a new practice? (*refer back to one they mentioned earlier WRT their own operation – For example, how did you decide to undertake X that you mentioned earlier*)

Genomics

Now I'd like to shift the focus of our conversation a bit to discuss genomics in the beef industry.

1) What role do you see genomics having in the beef industry?
    a. Any positive or negative impacts it can have?
    b. Do you see any link between genomics and environmental impacts in the industry?

2) Can you tell me a bit about why you might be or might not be interested in genomics?
    a. When it comes to your operation?
    b. When it comes to the industry overall?

3) What kind of information about the genes of your cattle do you have access to when making breeding decisions? (Maternal and paternal)
    a. As a cow-calf producer, what do you look for in terms of parental, paternal and maternal, traits? (what do you prioritise when breeding?).
        i. Do you use genetic information for this?
        ii. Do you think genomics can effectively target specific traits?

4) One of the reasons we are interested in genomics in the beef industry is the potential for greenhouse gas emissions reductions. The use of genomics in selective breeding for increased feed efficiency can reduce the greenhouse gas emissions from beef production. Can you tell me what you think about this use of genetic information?
    a. Would you consider this means of increasing the feed efficiency of your cattle? Why or why not?
    b. What would you take into account when making this decision?

5) Can you tell me a bit about what you think the industry's (or those promoting this use of genomics within the industry) intentions are regarding using genomics in selective breeding for feed efficiency and emission reductions?
    a. Do you trust these intentions?
    b. Do you think that YOUR best interests are being kept in mind?

6) Do you find that you question the potential benefits proposed by people promoting the use of genomics in breeding decisions?
    a. Why or why not?

7) Do you have personal relationships within industry groups or organizations that influence how you perceive the use of genomics? What are the characteristics of this relationship or person that allow this? Does trust play a role?
    a. [Getting at interpersonal trust vs. institutional or organisational trust.]

8) Do you think there are ethical considerations to keep in mind in this situation?

Trust

Clearly there is a lot to consider in making decisions about the environment, about genomics, along with all the other decisions you have to make in your operation. I'd like to hear about how trust in different individuals, groups, or information sources influences your decisions and practices. Other theories and studies suggest that trust can have an impact but don't really delve into how – this is what I'd like us to talk about. We'll talk about some general ideas and then use a mapping exercise to help go into more depth.

1) When you think about trust generally, how do you see it playing a role in your farm practices? (trust in who/what? Distrust or skepticism?)
    a. In your dealings with the rest of the beef industry?
    b. In your practices with environmental impacts?
    c. In thinking about the application of genomics?

2) Does trust simplify decisions about your practices?

3) How have you noticed that feelings of trust develop or occur in your relationships with individuals in the industry?
    a. With groups?

4) How does your level of trust in the people encouraging a given practice, such as a BMP or using genomics for increased feed efficiency, influence you're engagement with that practice? (for example, if you trust the organisation encouraging you to fence off wetlands are you more or less likely to go to an information session about fencing off wetlands).

5) Do you think being distrustful can help you make better decisions?
    a. Being skeptical?
    b. Where do feelings of distrust or skepticism come from?

Trust Mapping

Next I'd like to use a mapping exercise to dig in to some of these topics a little deeper. Sometimes visuals help further the conversation in interesting ways. There's no right or wrong way to draw this out – its just a way to try to get at the big picture and see individuals' operations within that.

Layers:

- Who is involved with genomics in selective breeding for increased feed efficiency? The big players – organisations, individuals, etc.

- Relationship with your farm – or potential relationship with your farm if you were to adopt this practice? (Direct and Indirect, individual contacts, organisational affiliations, occasional meetings or events that you attend)
- Trust – in which relationships is trust or distrust important, regarding decision making about using genomics to increase feed efficiency specifically.
- Is there anything you think is missing?

Discussion:
Now I'd like for us to go through the map and talk about what you've drawn out and trust in the relationships you've presented.

1) Generally, would you like to comment on the map?

2) What are your expectations of the individuals and groups on the map?

3) For each relationship where trust is important, explain **why**?
    a. Trust the INTENTIONS or the ABILITY of the person/group?
    b. Level of trust?
    c. What words would you use to describe the persons/groups that you trust (trust a lot)? That you distrust (distrust a lot)?

4) For the other relationships, where trust is not important, why doesn't trust play a role?

Possible things to ask if seeming relevant

5) Are you vulnerable in any of these relationships? Does trust influence your willingness to accept this vulnerability?

6) Are you dependent in any of these relationships? Does this dependence impact the role of trust in this relationship?

7) How do you think this map would compare to one completed for a different practice such as *[one the participant has mentioned]*?
    a. What about the use of genomics makes this map unique?

8) Do you have a personal experience with genomics and how your feelings of trust or distrust influenced your decision making?

That is the end of my questions. Is there anything else you would add anything – related ideas or experiences that we haven't covered? Thoughts on the discussion we've just had?

Appendix B – Interview Guide: Genomics Researcher Interviews

General Genomics and Selective Breeding for Increased Feed Efficiency
To start off with, can you tell me a bit about your work – how do you fit in to the genomic, cattle, breeding picture?

People often say that producers have been selectively breeding forever. What is changing in or new about breeding in the industry currently? In the future? *(EPDs vs. genetically enhanced EPDs? Etc).*

Where do you see genomics being picked up in the industry?

- Who do you see as pushing for or demanding the increased use of genomics in the beef industry? Why do you think they want this?
- How do you see cow/calf producers accessing or using genomics?

What sort of traits are currently the focus of genomic research, with respect to the beef industry?

- Why the focus on these?
- Who will benefit the most from cattle with these traits?
- Is there a risk of inherent trade offs? Or simply neglecting other beneficial traits?

If a cow/calf producer were to express concern that genomics can't accurately address the traits that most affect their operations – complex traits impacted by many features such as longevity, or subjective/context specific traits such as good feet – what would you say to them?

In a ranching context, animals interact with and are affected by their environment. Can you tell me a bit about how and if genomics can help accurately predict how traits will manifest in different contexts?

General Environment
What sort of environmental impacts or outcomes can occur with incorporating genomics into producers' breeding decisions? Benefits? Risks?

- Specifically, how can using genomics to selectively breed for increased feed efficiency be beneficial for the environment?
    - (E.g. Emissions reductions – by how much?)

Feed Efficiency and Environment
Can you tell me a bit about where feed efficiency fits in to the study of genomics in cattle?

- How much is known about the genes that influence feed efficiency?
- How much more needs to be done to increase the accuracy of feed efficiency breeding values?
- Are there tradeoffs associated with attaining higher feed efficiency?

What sort of benefits are there for producers?

- Who, which sectors, stand to benefit the most from feed efficient cattle?

Do you think individuals within the beef industry view feed efficiency as a way reducing their environmental impact (or is it more of a bottom line based decision? *Does this matter?*)?

If increased feed efficiency were to be effective as a long term emissions reductions measure in the industry, where along the supply chain does it need to be adopted?

Trust and Risks

What are the risks to the cow/calf producer of using genomics generally?

- to selectively breed for increased feed efficiency?

Are there any points in the creation or sharing of information at which producers are dependent on others in the system?

- Are producers vulnerable in the relationships of dependency?

In your view, do you see producers trusting the ability of researchers involved with genomics?

Do you think that producers see researchers involved with genomics as protecting their best interests?

Do you think that producers see industry members (other sectors) involved in genomics as protecting their best interests?

How do you see trust fitting in to producer decision making when it comes to selectively breeding for increased feed efficiency?

- Open to additional ideas or comments -

Appendix C – Information Sheets

Information Sheet for Producer Interviews

Understanding Beef Producer Practices Impacting the Environment

Background: You have been invited to participate in a graduate studies research project. The purpose of this research is to explore how cow-calf producers make decisions about the environmental impacts from beef production. We are interested in understanding how and when trust influences on-farm practices. Some of these practices have local impacts that can be seen on the farm. Other practices may have global impacts, such as greenhouse gas emissions that contribute to climate change. Many producer practices can be good for the environment. Both types of impacts and practices will be explored in this study. The use of genomics in selective breeding for increased feed efficiency will also be discussed to help us understand what producers think about this technology.

Purpose: This study can help enhance the sustainability of beef production by learning about why and how producers use environmental best practices. It will also add to existing theories about trust and environmental practices. These theories can be useful in real life.

Benefits and Risks: Participants can benefit from hearing a variety of views, thinking about and sharing their personal views, and learning about practices in another beef producing region. If you have to travel to participate you will be compensated in keeping with university policy. We do not foresee any risks associated with participating in this study.

Study Procedures: We are inviting you to participate in an in-depth interview about your perspectives on this topic. Participation is completely voluntary. In addition to discussing several questions, you will also be asked to draw and discuss a map of parties involved in genomics in the beef industry and impacts on decision making and practices. The interviews will take place at a time and place that is convenient for you and will last approximately 1.5 hours. If you agree, the interview will be audio recorded. The recording be securely stored and transcribed with your name removed. You may view this upon request. A researcher may contact you to follow up after the interview.

Confidentiality: No identifying information will be shared. Data collected will be safely stored to protect confidentiality. Only the researchers listed below will see the transcripts in full. Direct anonymous quotes from the transcripts may appear in future papers or reports. Information will be used in a graduate student thesis, academic publications, and project reports or presentations. You may view these upon request.

Voluntary Participation: If you agree to participate you may withdraw at any time, without penalty. During the interview you can refuse to answer any question and you can stop participating at any time. You may also withdraw at any time within three months of

the interview by contacting any of the researchers listed below. If you choose to withdraw completely none of the information you have provided will be used in the project.

Feel free to contact the researchers listed on page 2 with any concerns or questions about this project.

Information Sheet for Researcher Interviews

Understanding the Environmental Practices of Beef Producers

Background: You have been invited to participate in a graduate studies research project. The purpose of this research is to explore how cow-calf producers make decisions about the environmental impacts from beef production. The use of genomics in selective breeding for increased feed efficiency is also discussed to help us understand what producers think about this technology. We are interested in understanding how and when trust influences related on-farm practices. As part of this, it is necessary for us to understand the technology and its potential application and implications in the beef industry. Understanding the related research can provide context and space for comparison.

Purpose: Overall, this study can help enhance the sustainability of beef production by learning about why and how producers use environmental best practices. The specific purpose of this interview is to assist in understanding the potential role of genomics in environmental practices. This project will also add to existing theories about trust and environmental practices. These theories can be useful in real life.

Benefits and Risks: As an expert in this field, you may benefit from understanding producer perspectives and the role of trust in making this use of genomics socially feasible. We do not foresee any risks associated with participating in this study. If you have to travel to participate you will be compensated in keeping with university policy.

Study Procedures: We are inviting you to participate in an in-depth interview about the application of genomics in the beef industry and the use of genomics in selective breeding for increased feed efficiency. Participation is completely voluntary. The interviews will take place at a time and place that is convenient for you and will last approximately 1.5 hours. If you agree, the interview will be audio recorded. The recording be securely stored and transcribed with your name removed. You may view this upon request. A researcher may contact you to follow up after the interview.

Confidentiality: No identifying information will be shared. Data collected will be safely stored to protect confidentiality. Only the researchers listed below will see the transcripts in full. Direct anonymous quotes from the transcripts may appear in future papers or reports. Information will be used in a graduate student thesis, academic publications, and project reports or presentations. You may view these upon request.

Voluntary Participation: If you agree to participate you may withdraw at any time, without penalty. During the interview you can refuse to answer any question and you can stop participating at any time. You may also withdraw at any time within three months of the interview by contacting any of the researchers listed below. If you choose to withdraw completely none of the information you have provided will be used in the project.

Feel free to contact the researchers listed on page 2 with any concerns or questions about this project.