GLOBAL CLIMATE CHANGE: PERSPECTIVES IN THE BC CATTLE RANCHING INDUSTRY

by

Mercedes (Sadie) Cox
B. Sc. Thompson Rivers University 2007
B. Jour Thompson Rivers University 2007

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Abstract

A quantitative analysis of the BC cattle ranching community in light of global climate change provides insight as to how stakeholder needs and observations can be included in future planning. This analysis is an important first step towards an understanding of existing capacity and identifying areas of focus. Over sixty percent of survey respondents believe that human activities are increasing the rate at which global climate changes occur. Cattle ranchers operating for less than 20 years were more likely to agree that human activities are increasing the rate of global climate change on comparison to those operating more than 40 years. This may be a reflection of the fact that the concept of climate change has gained more public acceptance in the past two decades and would likely be perceived as a legitimate risk to an operation by those in this category in comparison to those who have been operating for a long period of time and tend to rely on experiential or embedded knowledge. Operation scale in terms of head of cattle appears to influence perceptions of localized climate variation on rangelands due to global climate change and changes in forage productivity and quality on a regional scale. Regional analysis provided some areas of potential focus for programs that would assist producers in further adapting to changes in climate. Movement towards building adaptive capacity must be a collaborative effort. Including experiential and scientific knowledge will be crucial to reducing the vulnerability of this sector and building adaptive capacity.

Keywords: climate change, vulnerability, adaptive capacity, range management, British Columbia, livestock, policy.

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DEDICATION

This project is dedicated to my family, friends and community members who continued to endlessly support and inspire me, and—most of all—to the source of my motivation to continue to learn and conserve—my son.

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1. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) states that global climate change is undeniable (IPCC 2007). Predictions for the next two decades include a warming of 2.0°C which will induce many changes to the global climate system in combination with current rates of greenhouse gas emissions. Regional predictions include changes in wind patterns, precipitation and the prevalence of extreme weather events (IPCC 2007). These changes will undoubtedly impact grazing livestock systems which are sensitive to variability in climate and persist under different biogeoclimatic conditions.

Climate variability can often result in one of the three following "syndromes": desertification, woody encroachment and deforestation, and in combination represent a significant factor of global environmental change (Asner et al. 2004). A small-scale study of the possible impacts of woody encroachment on forage productivity in the grasslands on the interior of BC was conducted as part of this project (Appendix VI). The rise in global temperatures is expected to create an increase in drought, which will affect forage and crop production and could potentially result in increased desertification through the combined effect of lower rainfall, warmer temperatures and increased drought. These conditions will lead to increased variability of forage availability and production, contributing to reduced industrial and ecological sustainability (Nardone et al. 2010). The decreased abundance of forage for grazing will lead to intensified grazing pressure. Consequences of the intensified pressure include declining vigor and abundance of plants palatable to livestock and an increased abundance of less desirable plants, decreased soil fertility and reduced soil water absorption (Conner 1994).

Thornton et al. (2007) suggest the impacts of climate change will depend on the nature of and exposure to climate hazards and be dependent on two types of vulnerability: biophysical and social. They define biophysical vulnerability as the sensitivity of the natural environment to hazards and social vulnerability as the sensitivity and adaptability of the human environment. Vulnerability is also defined as the "propensity of human and ecological systems to suffer harm and their [relative] ability to respond to stresses imposed as a result of climate change effects" by Adger et al. (2007). Factors influencing social vulnerability include edification, environmental exposures, the distribution of resources, prior stresses and the involvement of social and government institutions.

The IPCC (Parry et al. 2007) defines vulnerability as the:

> *degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes […]a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system.*

Adaptation then, is a response aiming to reduce overall vulnerability to climate change and the capacity or potential to do so is referred to as social adaptive capacity (Ziervogel et al. 2006) and involves adjustments in both behaviour and in resources and technologies (Adger et al. 2007). These adaptive adjustments in natural or human systems to current or expected climatic variability either moderate harm or exploit beneficial opportunities (Parry et al. 2007). According to Dolan et al. (2001) there are two types of adaptation to climate change. A reactive adaptation occurs after the impacts of climate change have already been experienced, while anticipatory adaptation is proactive and initiated before the full impact has been felt. Nardone et al. (2010) provide an example of proactive adaptation, stating that livestock systems should seize any opportunities derived from climate variation and attempt to minimize potential threats. In the case of cattle ranching in BC, this could include taking advantage of the increased number of growing degree days and planning for drought or extreme weather events. Understanding the factors that influence management decisions in grazing systems is essential in building successful adaptive capacity and reducing vulnerability (Fig. 1-1).

Reducing social and economic vulnerability and increasing political capacity will go a long way in helping ranchers be more adaptable (Coles & Scott 2009). Flexibility in integrative management policies and programs is crucial in ensuring diverse needs are met (Wall & Smit 2005). Climate change impacts and adaptation issues need to be relevant to local concerns within both community and management planning. Planning instruments such as Official Community Plans, local zoning, regional planning districts and the provincial Agricultural Land Reserve (ALR) have the potential to be powerful tools, guiding the planning process (Walker & Sydneysmith 2008).

A qualitative analysis of the BC cattle ranching community in light of global climate change provides insight as to how stakeholder needs and observations can be included in future planning. This analysis is an important first step towards an understanding of existing capacity and identifying areas of focus. Stakeholder inclusion in the planning process will be fundamental to the success of not only local and regional policy and programs but in contributing to the overall success of capacity building. Producers with experiential knowledge will be key players in reducing vulnerability by facilitating the education of the industry. This collaborative process will facilitate the adaptation of agricultural and food systems to coping with the short and long-term impacts of climate change.

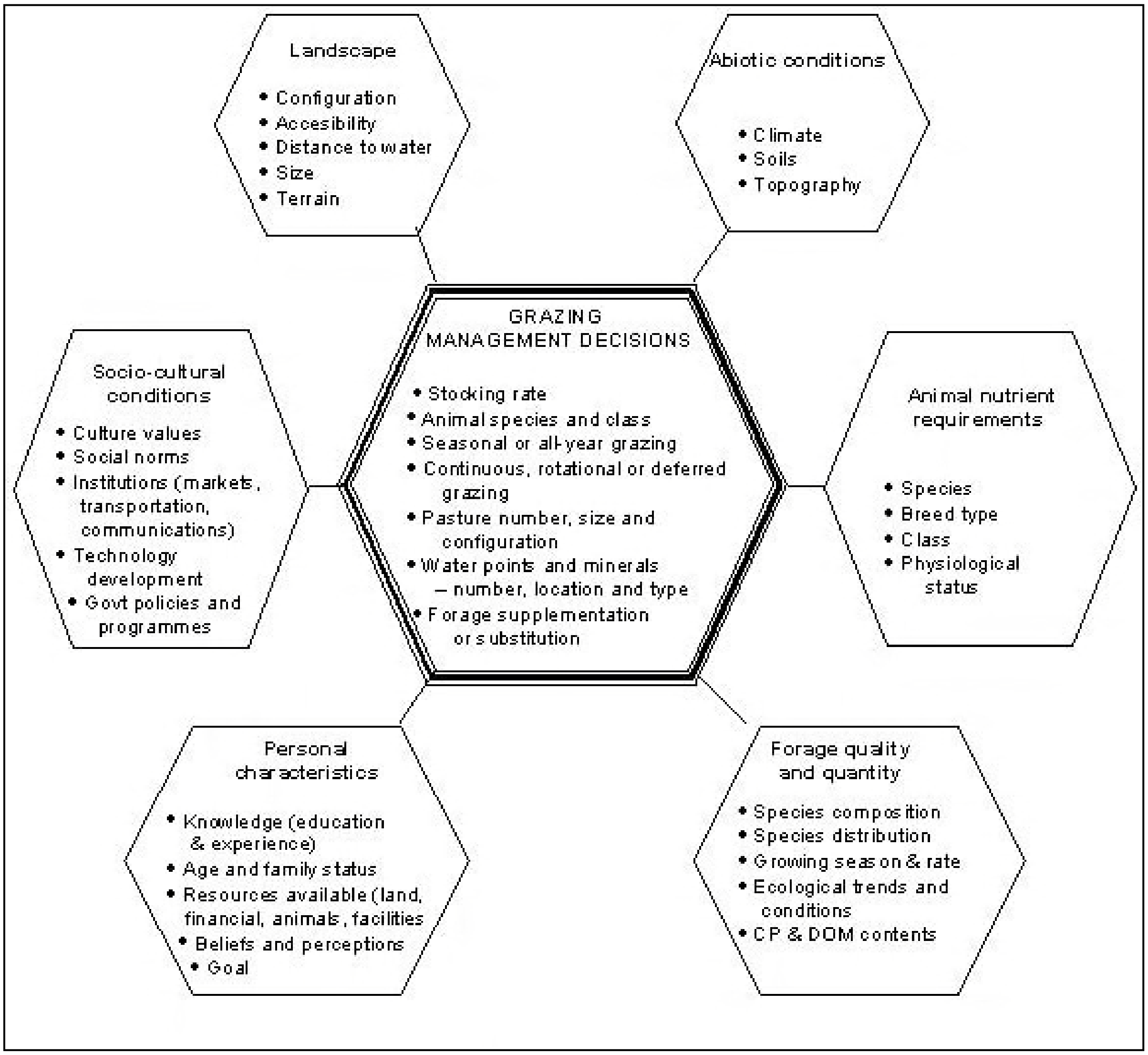


Figure 1-1: The grazing management environment consists of interrelationships between resources, activities and external influences and play a role in grazing management decisions (from Stuth et al. 1991).

A Quantitative Assessment of BC Cattle Producers' Perceptions on Climate change

2.0 Introduction

In its Fourth Assessment Report on climate change, the International Panel on Climate Change (IPCC) stated that global climate change and warming is "unequivocal" as evidenced by observations of increases in average global air and ocean temperatures, widespread melting of snow and ice and rising sea levels (IPCC 2007). The term "climate change" refers to any significant change in the state of the climate (e.g., changes in the mean and/or variability of its properties) over an extended period of time (decades or longer), whether due to natural variability or as a result of human activity (Parry et al. 2007; Ruddell et al. 2011).

Land classified as agricultural, which includes cropland, managed grassland and permanent crops, occupy 40-50% of the Earth's land surface (Parry et al. 2007; Smith et al. 2007), with managed grazing systems occupying more than 33 million square kilometres or 25% of the global land surface. These systems endure under different biogeoclimatic conditions and often result in one of the three following "syndromes": desertification, woody encroachment, and deforestation; in combination these syndromes represent a significant factor of global environmental change (Asner et al. 2004). Rising global temperatures are expected to create an increase in drought, which will affect forage and crop production, intensifying the process of desertification in these systems, reducing the carrying capacity of rangelands and other livestock systems. This could also increase the prevalence of other risk factors due to the availability and cost of grain (Nardone et al. 2010), making these systems more vulnerable and impairing their relative ability to adapt to changing conditions.

Considering that climate influences forage productivity (Antle 1996) and that global climate change will likely have a significant effect on plant growth, it is important to predict the effects of global climate change on forage productivity and forage quality and the impact global climate change will have on livestock management. Fluctuation in climate conditions usually results in variation in total yield of available forage, and thus, cattle production. This variability poses challenges to those depending on grazing land to support livelihoods (Conner 1994; Nardone et al. 2010). Crop and pasture growth in grazing-based livestock systems will be negatively affected by lower rainfall and increased drought conditions and by the effect of higher temperatures and solar radiation on animals (Nardone et al. 2010).

Agriculture is a major economic, social and cultural activity and remains highly sensitive to climate variations in all its different forms and locations (Howden et al. 2007). Soil, water, terrain and climate conditions provide both constraints and opportunities for agricultural production (Wall & Smit 2005) and, as such, environmental conditions are often a dominant source of the annual variability of regional production. Continued fluctuations in climate and weather patterns induced by global climate change will undoubtedly impact the future management of farming operations.

According to Zebarth et al. (2007), the general climate prediction for BC is for warmer and wetter winters and warmer and drier summers. Drier summers would occur from the combined effect of reduced precipitation and increased evaporation in some areas, resulting in an increased water deficit. The expected impact of climate change varies regionally because of the distinct nature of the climate and characteristics of each area. An increase is expected in annual variation in temperature and precipitation and the probability of extreme weather events—contributing to increased agricultural risk (Weber & Hauer 2003) and vulnerability.

There are few examples of adaptive range management strategies specific to climate change. This can be partially attributed to an inadequate perception of climate change as a risk to livelihoods. Perception of risk may be a function of proximal distance to a climate-related threat such as heat waves, droughts and forest fires, and whether the threat is perceived as endangering their way of life (Semenza et al. 2011). A recent study by Deressa et al. (2011) of Ethiopian farmers suggests adaptation to climate change is a two-step process, first requiring that an individual perceive climatic changes in order to achieve the second step, which is to respond accordingly. Values and beliefs concerning climate change—and from them policy norms and tolerances—can differ significantly according to the nature of economic and social development (Brown 2012).

In their study comparing public opinion on climate change in the United States and Canada, Borick et al. (2011) suggest that partisan affiliation also influences views of Canadians on global warming, finding that Conservative Party supporters were significantly less likely than supporters of all other parties to believe in global warming. Ruddell et al. (2011) propose these perceptions are influenced by political affiliation because public opinion on climate change has become a partisan issue. Borick et al. (2011) also found that climate change believers are divided on the root causes of global warming, citing both human activity and natural causes. Understanding opinions and perceptions about climate change will be a vital component in developing and facilitating effective policy options. Social adaptive capacity can be enhanced or inhibited by the character of decision-making relationships and policy planning as adaptation is influenced by the institutional, social, economic and political environment in which individuals operate. With two out of three Canadians believing that their province has already felt the effects of global warming (Borick et al. 2011), the social and political climate is supportive of developing mechanisms to increase adaptive capacity.

At the local level in BC, community planning is a key mechanism in increasing the adaptive capacity of stakeholders to consider and integrate the effects of climate change (Walker & Sydneysmith 2008; Thornton et al. 2009). Grounding support for adaptation and mitigation initiatives within the context of shared experiences and knowledge and improving public awareness would result in a more productive, less socially divisive model that blends scientific and experiential knowledge, reshaping public opinion about climate change (Ruddell et al. 2011). By the same token, the BC ranching community will be pivotal in successful and effective planning of climate change adaptation strategies.

It is crucial that range management practices are adaptable (as defined in Howden et al. 2007) and are able to address climate change issues that impact all aspects of ranching. Effective range management and associated policies need to consider changes in annual temperature and precipitation patterns. Undertaking a qualitative analysis of the ranching industry in light of climate change will provide a more comprehensive assessment of adaptive capacity via the inclusion of stakeholder observation (Coles & Scott 2009). A collaborative learning process would enable and facilitate the adaptation of agricultural and food systems to coping with the impacts of climate change (Thornton et al. 2009).

Possible adaptive responses include technological (such as seeding more robust or drought-tolerant crops), behavioural (such as changes in dietary choice), managerial (altering farm management practices/livestock species), and policy options (planning and infrastructure). Adaptation to climate change requires modifications to behaviour. Research alone cannot effectively contribute to the improvement of adaptive capacity without a comprehensive understanding of the context in which decisions about adaptation are made, and the capacity of decision makers to change (Thornton et al. 2009; IPCC 2007; Nardone et al. 2010).

2.1 Objectives

After reviewing possible survey implementation strategies, it was decided a mailed survey would be the best way to cover a large area, reaching all areas of British Columbia, Canada where ranching occurs. To be consequential, the assessment needed to consider possible differences between urban and rural communities in BC in terms of local policies, growth patterns, planning issues and social attitudes.

The objectives of the survey were to determine:

i. If ranchers believe that climate change is caused by human activities.
ii. If region, operation size or establishment time influence whether individuals attribute observed climatic changes on rangelands to climate change,
iii. If range management changes made in response to changes in climate varies by region, operation size or establishment time,
iv. To identify areas of focus for future education efforts and the application of adaptive range management strategies,
v. To identify means to enhance or create opportunities for adaptive capacity within the BC cattle industry.

It was expected that next to issues related to water quality and availability, feed prices and market prices for beef would be identified by livestock producers as increasing their vulnerability and influencing their relative ability to adapt to changes in climate. We also expected to see regional differences in management adaptations and operational concerns.

2.2 METHODS

2.2.1 SAMPLE SELECTION & SURVEY DELIVERY:

A mailed survey was chosen as the best approach to survey delivery based on a number of factors including economic viability, time and resource constraints. Although face to face interviews conceivably allow for more in-depth discussion of the interview questions and for clarification, this method would have considerably restricted sample size and breadth. The survey was designed in a manner consistent with recommendations by professionals in the field of survey methodology (Dillman 1983, 2000; Sanchez 1992; Puffer et al. 2004; Diaz de Rada 2005).

Many strategies, as described by Dillman (2000), Dillman et al. (2009), Kanuk & Berenson (1975), and Sanchez (1992) were employed to reduce nonresponse survey error. Surveys and cover letters were sent to 581 ranches, representing approximately half of the British Columbia Cattlemen's Association's (BCCA) provincial membership. The surveys and cover letters were mailed out in envelopes containing a postage-paid return envelope stamped with a postage stamp. The membership was categorized into six regions and half of the members within each area were randomly selected to receive the survey (Table 2.2-1). Mailworks, a third-party mailing service, was employed to work with the BCCA's membership list and to add codes to the surveys to maintain confidentiality. The BCCA allowed the use of their membership list for distribution on the condition that those selected to receive the survey would be able to maintain anonymity. The concern was that recipients may not otherwise feel comfortable responding or expressing an opinion regarding current government policy. In an attempt to reduce nonresponse error and to address this concern, anonymity was maintained.

Coding was used to determine a recipient list for the reminder postcard and for selecting three prize winners from the pool of respondents. The codes were also used in statistical analysis to discern regional differences in responses. Full disclosure regarding the coding was made clear to survey recipients on both the cover letter (Appendix II) and the surveys.

Table 2.2-1: Classification of survey mailings categorized by region based on the BC Cattlemen's Association membership directory.

Region	Members in Region	Number Mailed
Peace	180	90
Central	352	176
Cariboo	179	90
Thompson-Okanagan	334	167
Kootenay	93	47
South Coast	21	11

A reminder postcard was mailed 14 days after the initial mailing. The cover letter and post card also contained direct contact information (phone number and email address) of the researcher. The postcard also included the web address of the online survey (Fig. 2.2-1).

A reward mechanism was employed as an incentive to complete the survey and increase response rates. Two $50 prizes and one $100 prize were available to be won as store credit at a local retailer of choice. Respondents were entered into the contest once completed questionnaires were received. Research suggests employing reward mechanisms can significantly increase response rates (Oppenheim 1992; Dillman 2000).

An online version of the survey was also created using SurveyMonkey and distributed to members of the BC cattle ranching community through the BCCA via e-newsletters, the BCCA website and the Beef in BC magazine (Appendix IV). The web address for the online survey was included on the reminder postcards to provide an option for those who wished to complete the survey online. This mixed-mode approach to surveys is still relatively new and has been met with limited success depending on respondent demographics (Dillman et al. 2009).

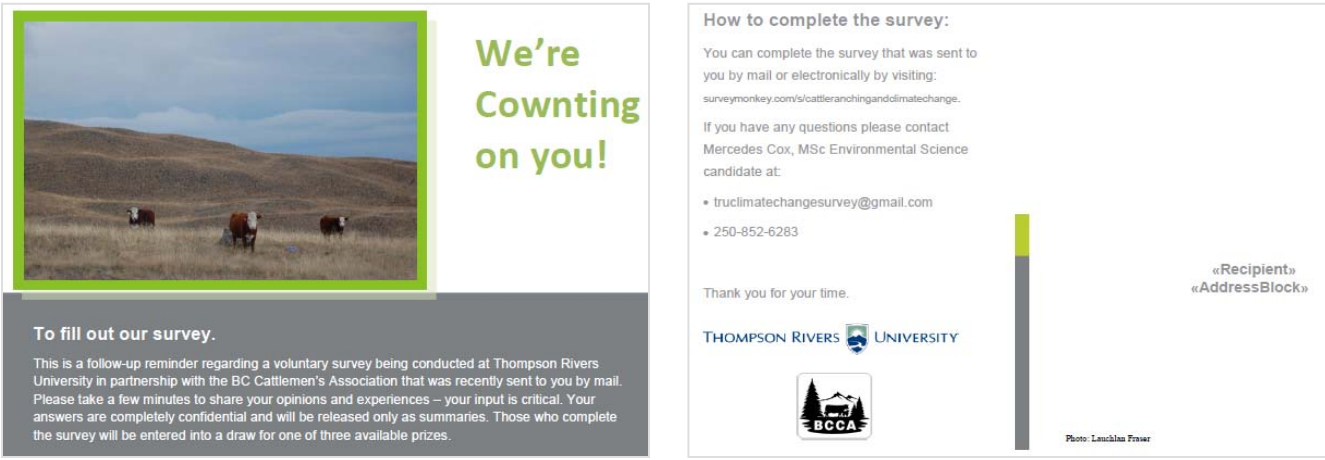


Figure 2.2-1: Front (left) and back (right) of reminder postcard sent two weeks after initial mailings to those who had not yet responded to the survey. Postcards were mailed by Mailworks based on the codes tracking respondents.

2.2.2 Survey design:

The survey design focused on characterizing cattle producers' present understanding of climate change and the degree to which they have adapted management practices in response to perceived changes in climate. Several steps were involved in the survey design including successive drafts and revisions based on recommendations from cattle producers, range management scientists and experienced survey designers. Once there was agreement that the survey design and content met the goals of the study, the survey was forwarded to the BCCA and select cattle ranchers for review and feedback regarding clarity and readability. Final revisions and changes were made to the survey based on the comments received, keeping the goals and objectives of the survey in mind.

Questions were grouped into four sections (climate change, management, background, and outreach) and question response options remained consistent throughout the survey. Possible recency (choosing the last response category) and primacy (choosing the first category) effects and the effects of non-opinion filters (offering a middle alternative on agree/disagree questions) were considered in the design, however, research suggests the overall impact of these effect is overrated and not of concern in mail surveys (Dillman 1991). The final version of the survey was comprised of four sections (Appendix III). Questions in the first section focused on global climate change and attempted to capture how climate change is perceived and defined by cattle producers. An attempt was also made to characterize the perceived nature of climatic changes, global and regional, through the design of the questions in this section.

The second section focused on range management strategies in relation to global climate change, and included questions about changes in range management strategies in response to perceived changes in climate and what types of incentives would be considered in the adaptive management of both private and Crown land. Information on the background of the respondents was collected in the third section, which included regional and operational questions. Respondents were also asked to identify the major challenges currently facing their operations. The final section was intended to identify areas and opportunities for further education and information and to elucidate the preferred medium of receiving this information.

2.2.3 Human Ethics Approval

Permission from the TRU Human Ethics Committee was required prior to making contact with potential survey respondents. Information that could possibly be used to identify respondents was kept in a secure location and accessible only to researchers directly involved in the project (Certificate of Approval # 10-11-S4).

2.3 Statistical Analysis

Descriptive statistics were generated for all questions. Frequency plots for most questions were also generated using regional data as the dependent variable and the question responses as the independent response variable. Frequency analysis using the number of cattle and length of time operating (i.e. operation size and establishment) as dependent variable with responses to questions from section one as the independent variable. Contingency tables were generated for multi-part questions. To explore whether establishment time of an operation affected perspectives about climate change, the same questions were also compared to the number of years an individual has been operating and the number of cattle per operation. The purpose was to see if there was any effect of location, operation size or establishment on responses to questions such as those pertaining to water and forage quality/availability, impact of the mountain pine beetle, information needs and preferences.

One-way analysis of variance (ANOVA) was carried out using background data gathered in section three (region, number of cattle and length of time operating) as independent variables and questions from section one of the survey as the dependant variable. An ANOVA was performed with the original categories according to the available response options for region, number of cattle and length of time operating and on regrouped data as data for operation size and establishment time were regrouped to create categories of comparable size. Multiple-response questions were analyzed using a univariate analysis of variance. Post hoc tests (Tukey HSD and Games-Howell (if equal variance was not assumed)) for multiple comparisons were used if significance was indicated by either an ANOVA or univariate analysis.

2.4 Results

A total of 287 surveys were returned (including 23 blank) for a 49% return rate. A number of surveys were excluded due to non-response bias (Ornstein 1998) where the survey was returned either incomplete or contained invalid responses. Some surveys were only partially completed but still contained usable data for some questions and that information was included in the results. An additional 22 surveys were excluded from the analysis due to either being improperly completed or the respondents self-identifying they were no longer actively ranching. A total of 242 surveys (42% usable) were used in the final analysis (Table 2.4-1).

Only 13 individuals chose to complete the survey online. This was unsurprising and in agreement with the findings of Dillman et al. (2009) that switching to a second mode of data collection (i.e., following up a mailed survey with a different survey mode option) isn't an effective means of reducing nonresponse error for mailed surveys. The online survey results were not included in the final analysis. All statistical analysis of the survey data was performed using IBM SPSS software (Version 19).

Table 2.4-1: Regional response rate to survey based on 230 surveys.

Region	Number mailed	Number returned	Regional response rate
Peace	90	32	36%
Central BC	176	64	36%
Cariboo	90	53	59%
Thompson-Okanagan	167	57	34%
Kootenay	47	33	70%
South Coast	11	2	18%

The Kootenay region had the highest rate of survey return followed by the Cariboo and an average return rate was achieved for the Peace, Central BC and the Thompson-Okanagan.

Only two surveys were returned from surveyed operations on the South Coast. These surveys were excluded from regional statistical analysis (n < 5).

2.4.1 POPULATION BACKGROUND DATA

Factors such as location, size of operation, establishment (number of years operating), land ownership (private vs. Crown lease), investment in Crown land (willingness to manage), engagement in additional agricultural activities and current operational challenges all provide some insight into this group of stakeholders.

Based on the BCCA membership list, the majority of operations are located in Central BC, followed by the Thompson-Okanagan and Cariboo regions. Thirty five percent indicated establishment of more than 40 years, with the longest operation being established for 147 years and twelve percent operating for 50 years (Table2.4-1). Average operating time for the remaining categories is eight years.

Table 2.4-1: Frequency analysis summarizing responses regarding the length of time cattle ranches have been in operation at current location.

Number of years operating			
Response options	Frequency	Percent	Cumulative Percent
Less than 5 years	16	6.7	6.7
6-10 years	15	6.3	13.0
11-15 years	19	8.0	21.0
16-20 years	26	10.9	31.9
21-25 years	17	7.1	39.1
26-30 years	16	6.7	45.8
31-35 years	21	8.8	54.6
36-40 years	24	10.1	64.7
More than 40 years	84	35.3	100.0
Total	**238**	**100.0**	

Participants were asked to indicate the category which most appropriately reflected their current operation size in terms of number of cattle. Close to 60% reported operations with 100 head of cattle or less (Table 2.4-2), which reflects the fact that the provincial average of cattle per ranch in B.C. is 95 (Table 2.4-3).

Table 2.4-2: Reported number of cattle per ranch.

Response options	Frequency	Percent	Cumulative Percent
0-50	65	27.3	27.3
50-100	63	26.5	53.8
100-200	48	20.2	73.9
200-250	15	6.3	80.3
250-500	28	11.8	92.0
over 500	19	8.0	100.0
Total	238	100.0	

Table 2.4-3: Semi-annual average number of cattle and calves per farm from 2010 – 2012. Average number of cattle per farm in BC as of January 2012 is 95, below the national average of 132. *Period I: data at January 1. Period II: data at July 1 (StatsCan table 003-0099).

Geography	Estimates	I 2010	II 2010	I 2011	II 2011	I 2012
British Columbia	Number of farms reporting cattle and calves	5820	5995	5655	5975	5660
British Columbia	Average number of cattle and calves per farm reporting	89	109	92	109	95
Canada	Number of farms reporting cattle and calves	99360	99550	96430	97115	95105
Canada	Average number of cattle and calves per farm reporting	130	140	129	143	132

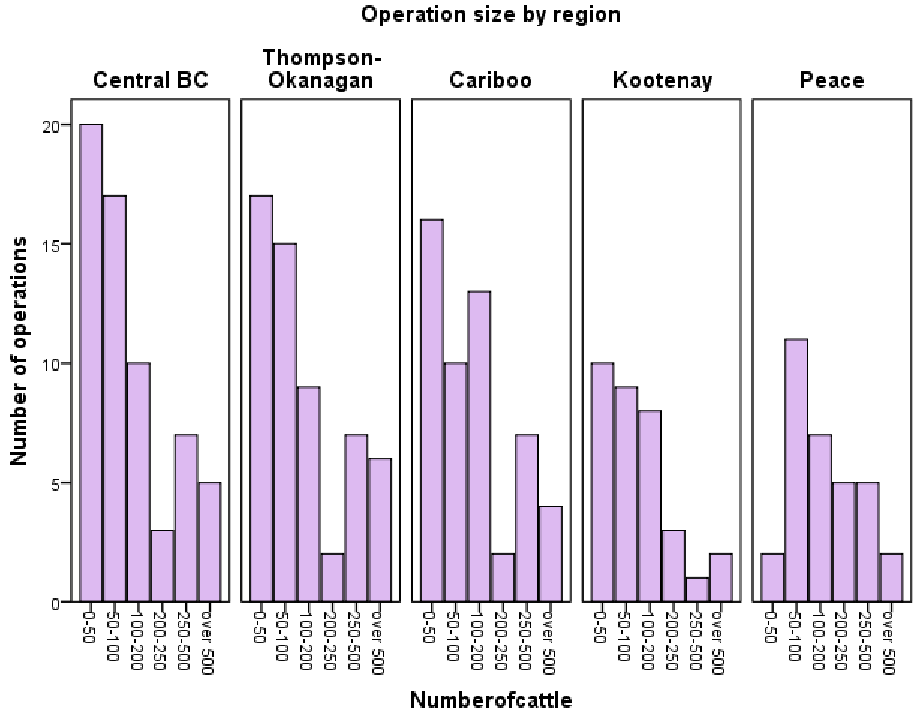


Figure 2.4-1: Number of operations by region. Each bar represents the number of operations of a given size based on the number of cattle.

There is a higher frequency of operations having between 0-100 head of cattle in Central BC and over 500 head of cattle in the Thompson-Okanagan (Fig. 2.4-1). Operations having between 100-200 cattle are most common in the Cariboo region, while those having 200-250 are most common in the Peace region. Participants were asked to indicate whether they engaged in any other agricultural activity and, if so, to estimate the scale of that activity in hectares. 38% of respondents stated they engaged in other agricultural activities. The most common secondary activity was growing hay for silage or forage, either for use in the existing operation or to supplement revenue (70%). Others had other livestock such as sheep, pigs and goats and identified a range of activities such as timber sales, agritourism (horseback rides), dairy cattle (for financial stability), egg production and Christmas tree farming.

Another representation of operation size was obtained by asking respondents to provide an estimated acreage in terms of private, Crown tenure, common/shared pasture and private lease land accessed for grazing (Table 2.4-4). Unfortunately, many respondents replied by providing an estimated percentage of each category without providing a total area. As there was no way to determine an estimated area from this information, these responses had to be excluded from the analysis. Anecdotally, most indicated that Crown grazing tenures comprised a significant proportion (85-100%) of the land used for operating.

Table 2.4-4: Estimated area of rangeland used by operations (n=150).

Response options	N	Minimum (acres)	Maximum (acres)	Mean	Std. Deviation
Private land	150	10	30000	1232.91	2789.15
Crown land	88	1	1000000	35944.98	115705.49
Common/shared	13	0	100000	10041.31	27584.94
Private lease	69	30	50000	1738.55	6101.60

Table 2.4-5: Response to the question: "if you hold Crown tenure, please estimate how much effort you are willing to invest in maintaining the health of the Crown-tenured land."

Response options	Frequency	Percent	Cumulative Percent
low investment	24	16.4	16.4
2	24	16.4	32.9
3	41	28.1	61.0
4	30	20.5	81.5
high investment	27	18.5	100.0
Total	146	100.0	

Close to 50% of respondents were willing to make a significant investment in maintaining Crown-tenured land, 28% were neutral and roughly 35% would make a low investment (Table 2.4-5). Many respondents noted they already invest in maintaining the rangelands they use, Crown or otherwise. Option 3 (neutral) was the most frequent option chosen, but the majority of responses indicate willingness.

Market prices for cattle was identified as the most significant challenge facing cattle ranching operations, followed by fuel and grain/hay costs (Fig. 2.4-2). These results differed from the expected issues related to water quality and availability. Global climate change was consistently identified in all regions as the least significant challenge. Some regional variation exists in terms of grain/hay costs, water availability and family involvement/successional planning.

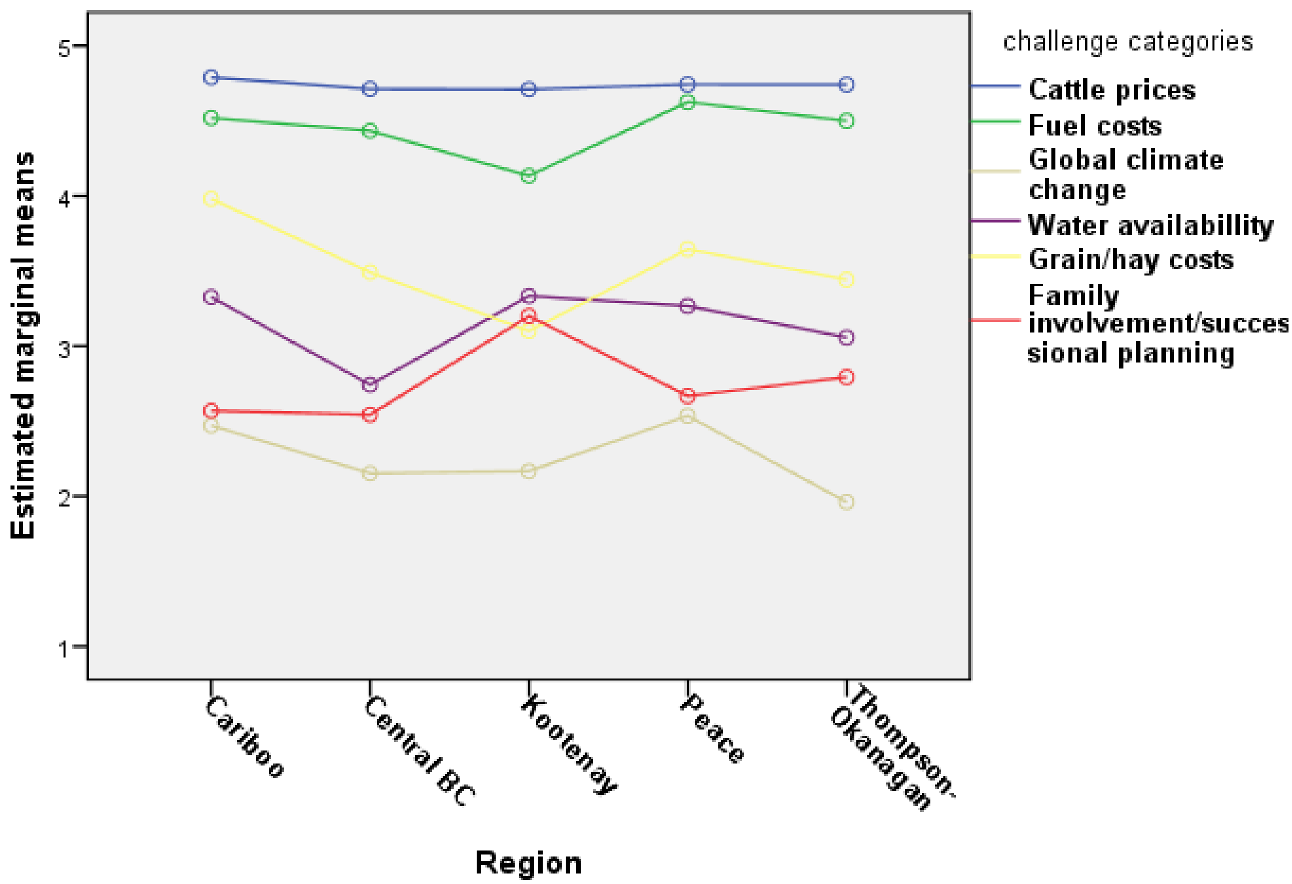


Figure 2.4-2: Major challenges currently facing operations by region. 1 = least significant, 5 = most significant.

2.4.2 CLIMATE CHANGE CHARACTERIZATION

One of the objectives of the survey was to determine the extent that cattle producers believe in global climate change. This section of the survey focused on trying to characterize that understanding by asking questions regarding what climate change is, asking respondents to identify factors normally associated with global climate change, and factors that may affect operations that are also associated with climate change (i.e.: water and forage quality/availability). When asked whether they agreed with the statement that “Human activities are increasing the rate at which global climate changes occur” more than 60% (n = 242) of respondents strongly agreed/agreed and 20% strongly disagreed/disagreed (Table 2.4-6).

Table 2.4-6: Response to question statement: “human activities are increasing the rate at which global climate changes occur.”

Response options	Frequency	Percent	Cumulative Percent
strongly agree	53	21.9	21.9
somewhat agree	102	42.1	64.0
neutral	37	15.3	79.3
somewhat disagree	28	11.6	90.9
strongly disagree	22	9.1	100.0
Total	242	100.0	

Table 2.4-7: Response to question statements listing factors associated with global climate change.

		Responses		
		strongly agree	somewhat agree	neutral
	Count	41	107	47
	% within	26.6%	27.6%	21.1%
	Count	33	119	48
	% within	21.4%	30.7%	21.5%
	Count	32	75	76
	% within	20.8%	19.4%	34.1%
	Count	46	82	50
	% within	29.9%	21.2%	22.4%

identified changes in annual precipitation as a factor, followed by 50% identify in annual temperature/change in frequency of severe weather events (Table 2 i0% disagreed with the association between changes in the length and timing (ıd global climate change. Respondents were asked to identify other factors they as: ı global climate change. Only nine participants responded to this option, citing v· ·thquakes, changes in bird migration and in forest composition as factors. A few par ɔ noted that cycling weather patterns is normal and not associated with global c ;e, selecting “strongly disagree” in the “other” category.

ate between perspectives regarding global climate change and regional change: ɔarticipants were asked to select the degree to which they agreed with the statem(nate on rangelands is changing because of global climate change. Over 50% of resp(:e changes in local climate on rangelands to global climate change and close to 20% :utral or disagree (Table 2.4-8). To ascertain what factors participants associa· nal changes in climate, participants were asked to characterize changes in access t ʏ of water and forage quality/productivity on any rangelands used. This is an important question as restricted access to water or a reduction in forage quality can have a significant impact on the long-term feasibility of an operation.

Table 2.4-8: Response to question statement: "local climate on rangelands is changing because of global climate change."

Response options	Frequency	Percent	Cumulative Percent
strongly agree	33	14.0	14.0
somewhat agree	94	39.8	53.8
Neutral	55	23.3	77.1
somewhat disagree	27	11.4	88.6
strongly disagree	27	11.4	100.0
Total	236	100.0	

Table 2.4-9: Response to question statement: "access to and availability of water has decreased as a result of regional climate change."

Response options	Frequency	Percent	Cumulative Percent
strongly agree	55	23.1	23.1
somewhat agree	77	32.4	55.5
Neutral	44	18.5	73.9
somewhat disagree	45	18.9	92.9
strongly disagree	17	7.1	100.0
Total	238	100.0	

Over 50% agreed that access to and availability of water has decreased regionally while 26% disagreed (Table 2.4-9). 50% indicated a change in forage productivity associated with regional changes in climate, close to 25% said there was no change (Table 2.4-10). Responses regarding forage quality were only marginally different from each other with 35% agreeing, 34% being neutral and 32% disagreeing (Table 2.4-11).

Table 2.4-10: Response to question statement: “there has been a change in forage productivity on rangelands you use because of regional climate change.”

Response options	Frequency	Percent	Cumulative Percent
strongly agree	40	16.9	16.9
somewhat agree	79	33.3	50.2
Neutral	60	25.3	75.5
somewhat disagree	40	16.9	92.4
strongly disagree	18	7.6	100.0
Total	237	100.0	

Table 2.4-11: Response to question statement: “there has been a change in forage quality on rangelands you use because of regional climate change.”

Response options	Frequency	Percent	Cumulative Percent
strongly agree	21	8.9	8.9
somewhat agree	61	25.7	34.6
Neutral	80	33.8	68.4
somewhat disagree	46	19.4	87.8
strongly disagree	29	12.2	100.0
Total	237	100.0	

As climate change is associated with the spread of the mountain pine beetle throughout BC (Drolet 2012), it was important to describe any impact the loss of any forest may have had on rangelands as a result of the mountain pine beetle. The response options for this question allowed for the indication of positive, negative or no impact (neutral). A follow-up question asked respondents to expand on their category selection by briefly stating how their operation was affected.

Table 2.4-12: Response to question statement: "the destruction of forests caused by the pine beetle has impacted my ranching operation."

Response options	Frequency	Percent	Cumulative Percent
very positively	36	15.4	15.4
positively	42	17.9	33.3
Neutral	84	35.9	69.2
negatively	34	14.5	83.8
very negatively	38	16.2	100.0
Total	234	100.0	

Statements indicating how mountain pine beetle has affected cattle ranching operations: positively (33%), negatively (31%) and neutral (36%) (Table 2.4-12). Based on regional data, these results are reflective of regional differences in biogeoclimatic zones and forestry composition. Some positive impacts identified include greater access to range/increased foraging areas, increased forage productivity and more fires to stimulate rejuvenation. Most responses related to the "neutral" category were from regions unaffected by mountain pine beetle. The following comment encapsulates most of the negative impacts identified in this response section:

> *Value of timber is gone so can't be used as capital for improvements; destruction of fences due to dead trees falling constantly; makes for poorer bush pasture - limits movement of cattle due to downfall.*

Other negative impacts include the loss of natural barriers (resulting in the need for more fences), loss of shelter from the elements, increased wind, faster spring run-off (less water retention), increased soil erosion, increased risk of forest fire and loss of income source via lower stumpage rates or an inability to harvest and/or market dead/fallen trees.

Table 2.4-13: Five one-way ANOVA analyses of questions regarding climate change beliefs and associated factors, categorized by region.

*South Coast region excluded from analysis (n = 2).

	Do you think human activities are increasing the rate at which global climate changes occur?		Local climate on rangelands is changing because of global climate change.		Access to and availability of water has decreased as a result of regional climate change.		There has been a change in forage productivity on rangelands you use because of regional climate change.		There has been a change in forage quality on rangelands you use because of regional climate change.		The destruction of forests caused by the pine beetle has impacted my ranching operation.	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Regional responses	3.389	.010*	1.429	.225	3.858	.005*	1.275	.280	1.502	.202	1.379	.242

There were significant differences in beliefs in the Thompson-Okanagan region in terms of human activity influencing the rate of global climate change and access to and the availability of water (Table 2.4-13). Significant differences were observed in the one-way analysis of variance comparison of regional response means to the question regarding whether human activities are affecting the rate of global climate change (eta-squared = 0.05), whether access and availability to water has decreased due to regional climate change (eta-squared = .059). Post hoc Tukey HSD analysis results indicate a significant response variance regarding whether human activities are increasing the rate at which global climate changes occur between the Thompson-Okanagan, Cariboo and the Peace regions (Fig. 2.4-3).

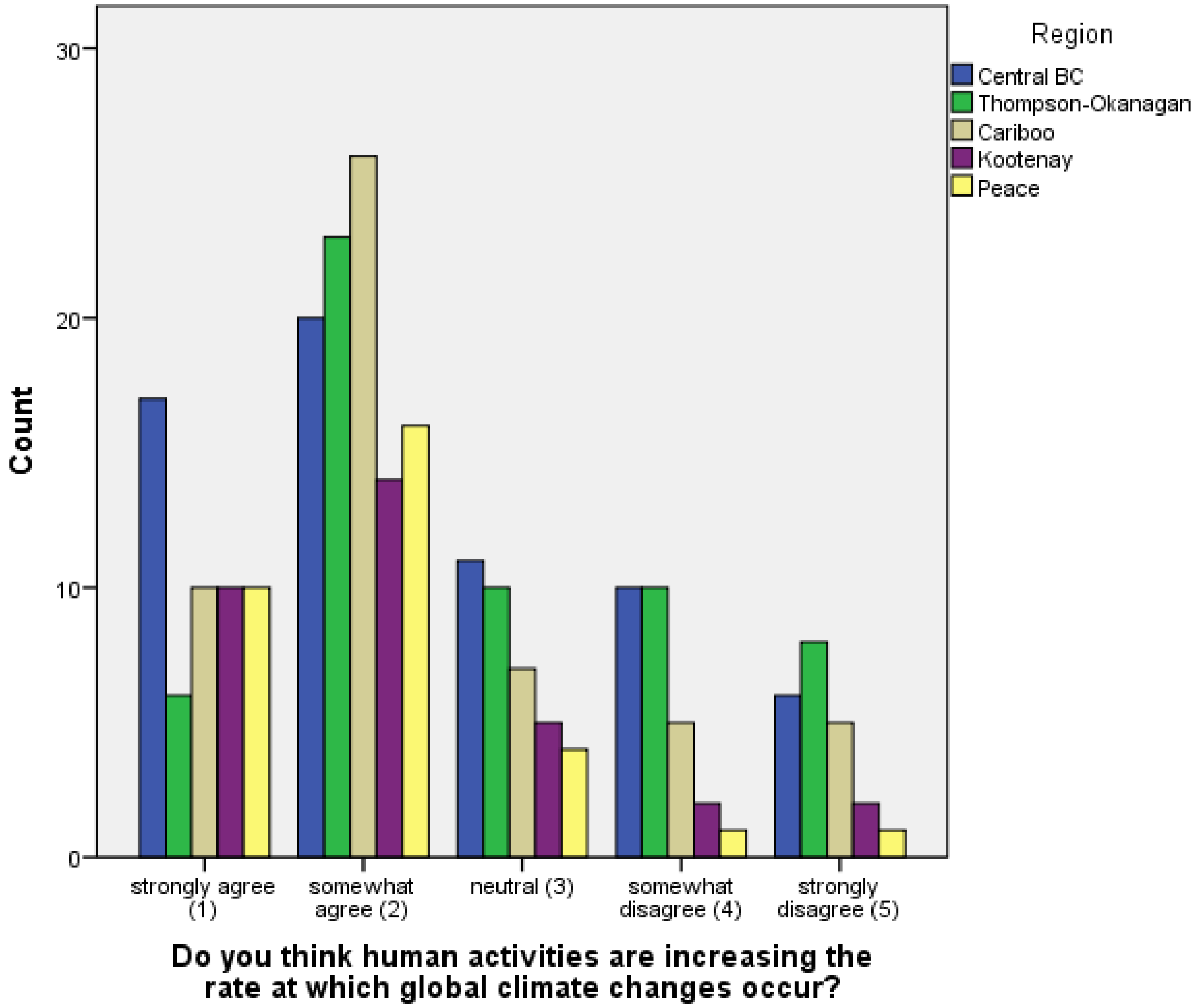


Figure 2.4-3: Regional frequency of responses depicting differences in agreement between the Thompson-Okanagan, Cariboo and Peace regions in response to the noted question.

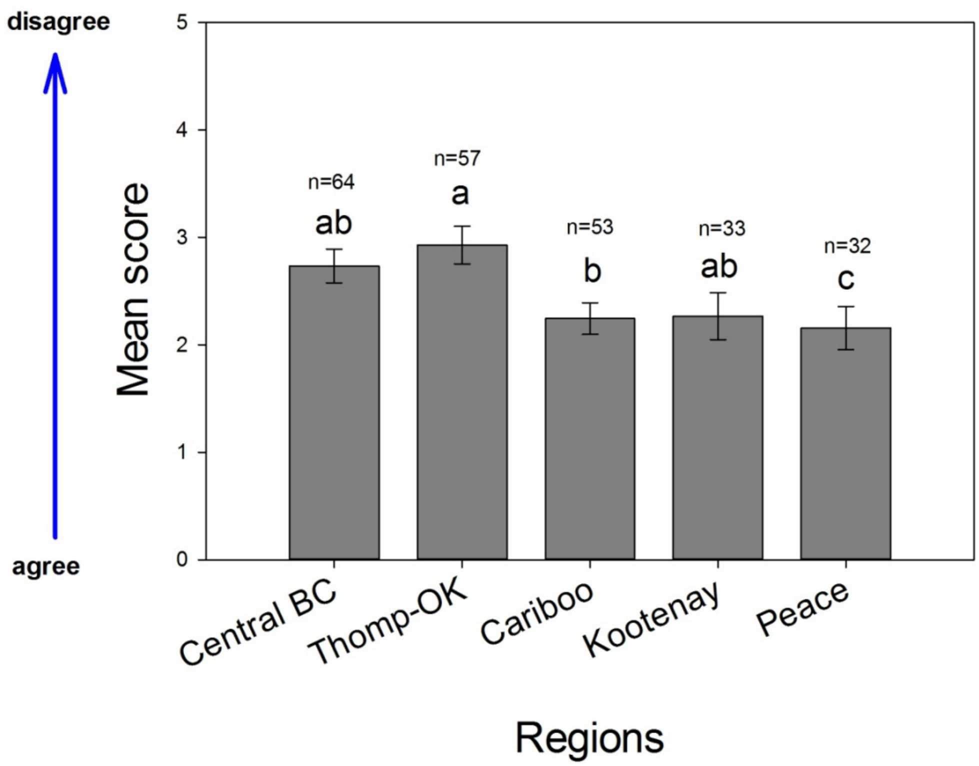


Figure 2.4-4: Regional differences in mean in responses to the question statement: Human activities are increasing the rate at which global climate changes occur. 1 = strongly agree – 5 = strongly disagree. (a) indicates the mean responses from the Thompson-Okanagan were significantly different from the mean response option in the Cariboo (b) and Peace (c). No other significant differences were observed in the responses from other regions (ab). Error bars indicate standard error of the mean for each category.

Significant difference in the mean of responses from the Thompson-Okanagan and Peace regions regarding decreasing access to and the availability of water were indicated by Tukey analysis (Fig. 2.4-5).

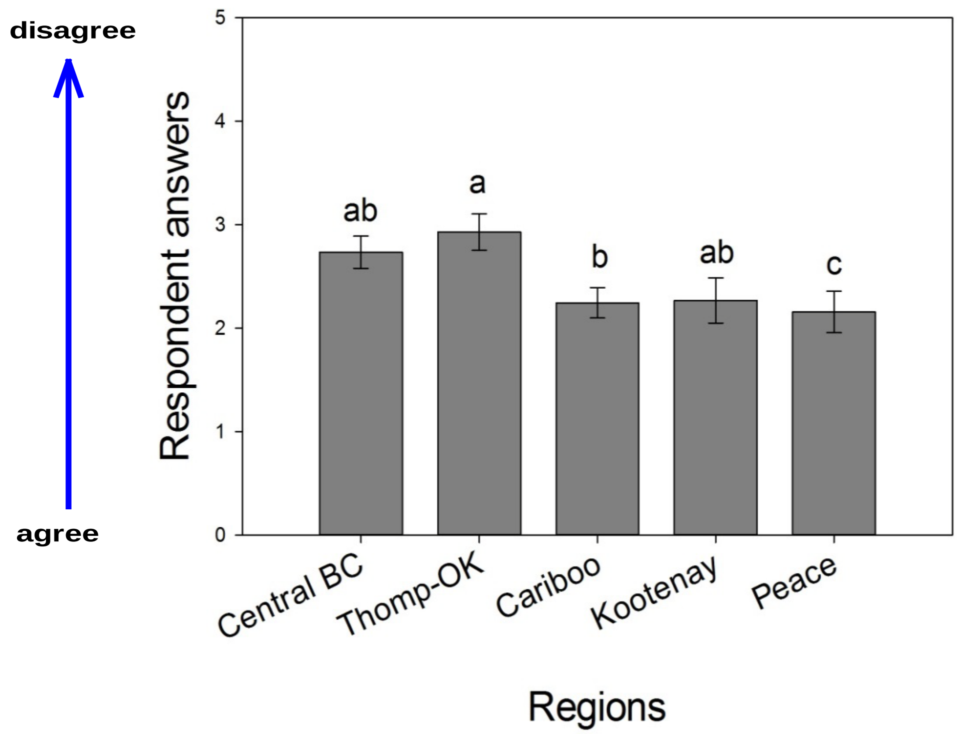


Figure 2.4-5: Regional differences in mean in responses to the question statement: Access to and availability of water has decreased as a result of regional climate change. 1 = strongly agree – 5 = strongly disagree. (a) indicates the mean responses from the Thompson-Okanagan were significantly different from the mean response option in the Peace (b) and the Cariboo (c). No other significant differences were observed in the responses from Central BC or the Kootenays (ab). Error bars indicate standard error of the mean for each category.

Analysis was also performed to investigate whether establishment time influenced responses to the same set of questions. It was hypothesized that operators of well-established cattle ranches would have greater observational capacity and be more aware of changes in climate and would be more likely to attribute any variations to global climate change.

Table 2.4-14: Five one-way ANOVA analyses of questions regarding climate change beliefs and associated factors in relation to establishment time (i.e.: number of years operating at current location).

	Do you think human activities are increasing the rate at which global climate changes occur?		Local climate on rangelands is changing because of global climate change.		Access and availability to water has decreased as a result of regional climate change.		There has been a change in forage productivity on rangelands you use because of regional climate change.		There has been a change in forage quality on rangelands you use because of regional climate change.		The destruction of forests caused by the pine beetle has impacted my ranching operation.	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Number of years operating	2.645	.009*	.991	.444	1.038	.408	.751	.646	.755	.643	.569	.803

A one-way analysis of variance showed that there was a difference in response regarding whether participants believe human activities are increasing the rate of global climate change based on the number of years they have been operating (Table 2.4-14). Post hoc analysis indicated a significant difference ($p > 0.05$) between means for those respondents ranching for 31-35 years and for more than 40 years (Fig. 2.4-6). Establishment time did not appear to influence any other responses to perspectives about climate change.

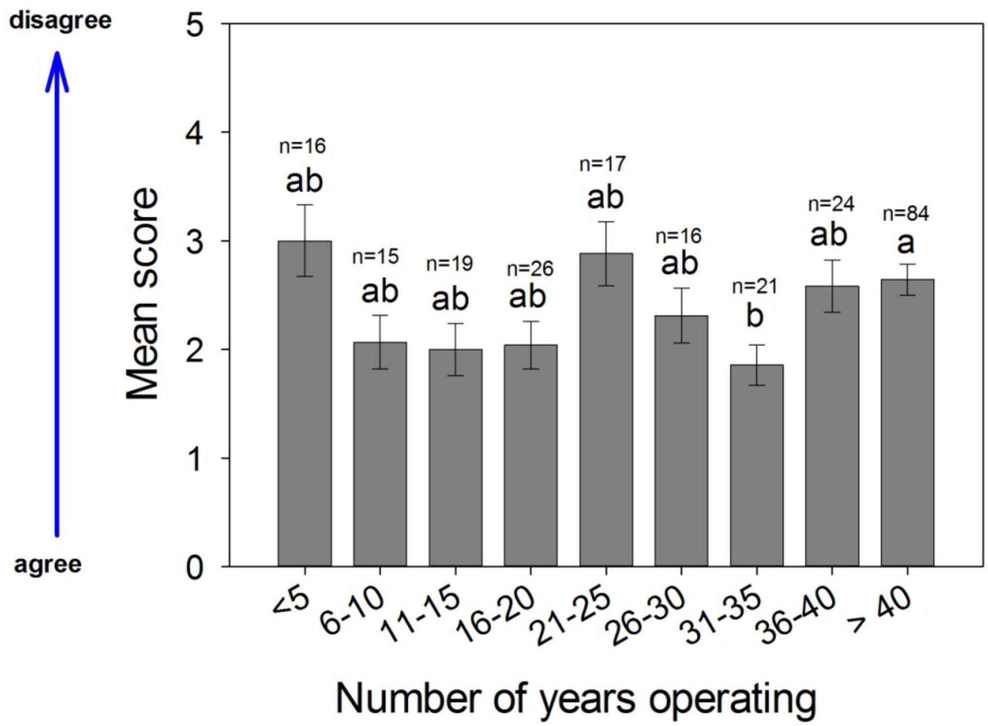


Figure 2.4-6: Differences in mean in responses to the question statement: Human activities are increasing the rate at which global climate changes occur based on establishment time. 1 = strongly agree – 5 = strongly disagree. (a) indicates the mean responses from those operations established for 40 years or more and (b) 31-35 years were significantly different from all other categories (ab). Error bars indicate standard error of the mean for each category.

As the categories used in this analysis were unevenly distributed, the data was regrouped into evenly distributed categories. Results from the regrouped analysis indicate the results were significant to a p=0.10 with those operating less than 20 years being more likely to agree with the statement in comparison to those operating for more than 40 years (Fig. 2.4-6).

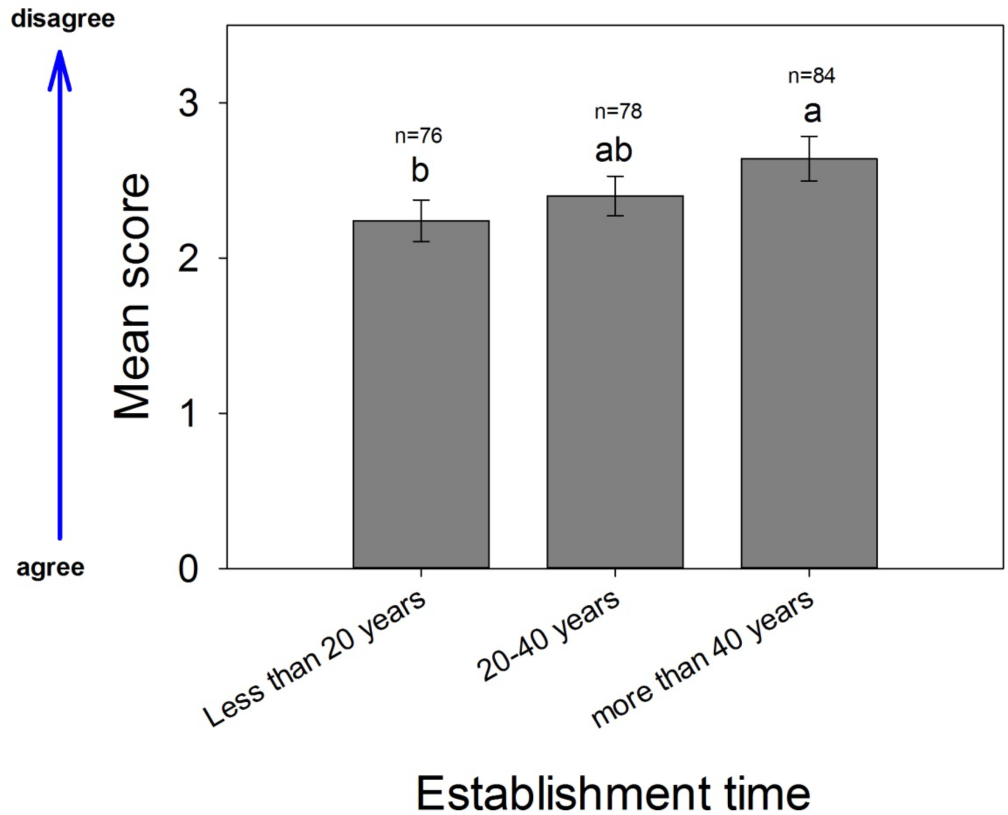


Figure 2.4-7: Differences in mean in responses to the question statement: Human activities are increasing the rate at which global climate changes occur based on establishment time. 1 = strongly agree – 5 = strongly disagree. Those established for more than 40 years were more likely to disagree with the statement.

The last factor considered was the scale of the operation in terms of head of cattle. Results suggest that the scale of operation influenced perspectives regarding local climate on rangelands and influenced responses to questions about perceived changes in forage productivity and forage quality (Table 2.4-15).

Table 2.4-15: Five one-way ANOVA analyses of operation size (based on number of cattle) and questions regarding climate change beliefs and associated factors.

	Do you think human activities are increasing the rate at which global climate changes occur?		**Local climate on rangelands is changing because of global climate change.**		**Access and availability to water has decreased as a result of regional climate change.**		**There has been a change in forage productivity on rangelands you use because of regional climate change.**		**There has been a change in forage quality on rangelands you use because of regional climate change.**		**The destruction of forests caused by the pine beetle has impacted my ranching operation.**	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Number of cattle	1.571	.169	3.654	.003*	1.029	.401	2.213	.050*	3.068	.011*	1.175	.322

One-way analysis of variance indicated a significant response difference regarding whether local climate is changing on rangelands because of global climate change (eta-squared=.032), if there has been a change is forage productivity (eta-squared=.046) and forage quality (eta-squared=.063) because of regional climate change and the number of cattle per operation (i.e. operation size) (Table 2.4-15). Post hoc analysis indicated a significant difference at the 0.05 level in means of responses for the following categories (0-50 cattle, 100-200, 250-500 and over 500 cattle) in relation to the statement that local climate on rangelands is changing because of global climate change (Fig. 2.4-8).

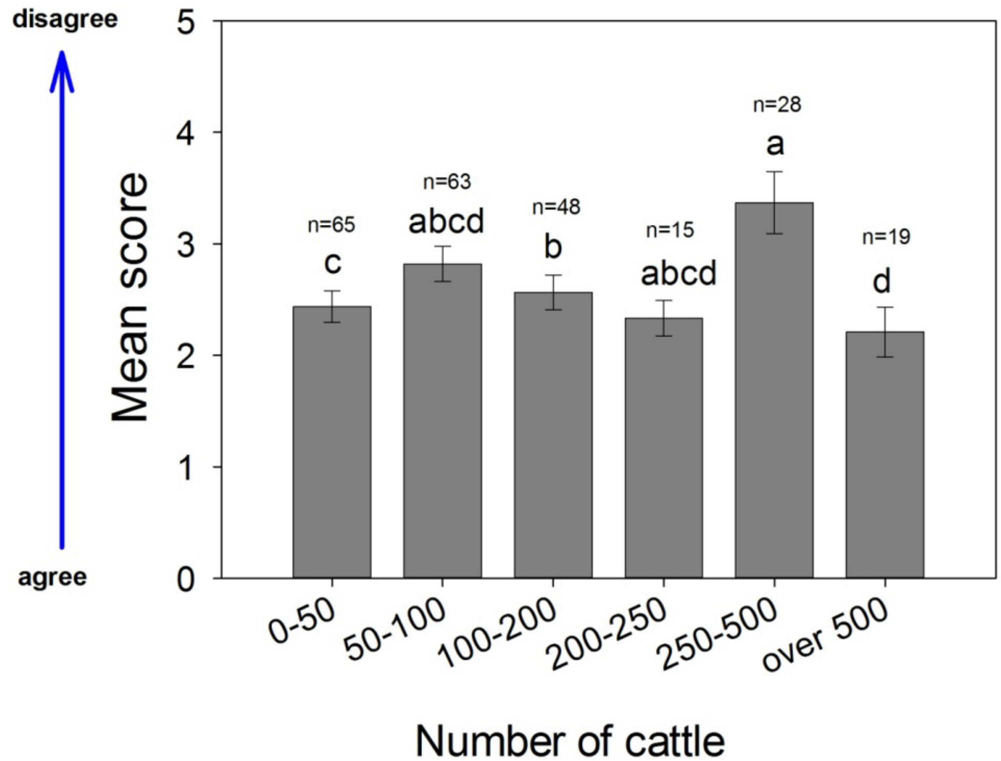


Figure 2.4-8: Differences in mean in responses to the question statement: Local climate on rangelands is changing because of global climate change. 1 = strongly agree – 5 = strongly disagree. (a) indicates the mean responses from those operations with between 250-500 cattle, (b) 100-200 cattle, (c) 0-50 cattle, and (d) over 500 cattle were significantly different from all other categories (abcd). Error bars indicate standard error of the mean for each category.

As the categories used in this analysis were unevenly distributed, the data was regrouped into more evenly distributed categories. The results from the regrouped ANOVA indicated a significance of p=0.106 to the question statement: Local climate on rangelands is changing because of global climate change, but post-hoc analysis indicated no significance (Fig. 2.4-9). Differences between the regrouped categories were found to be significant to p=0.118 between those with 0-50 and over 250 cattle(Fig. 2.4-11).

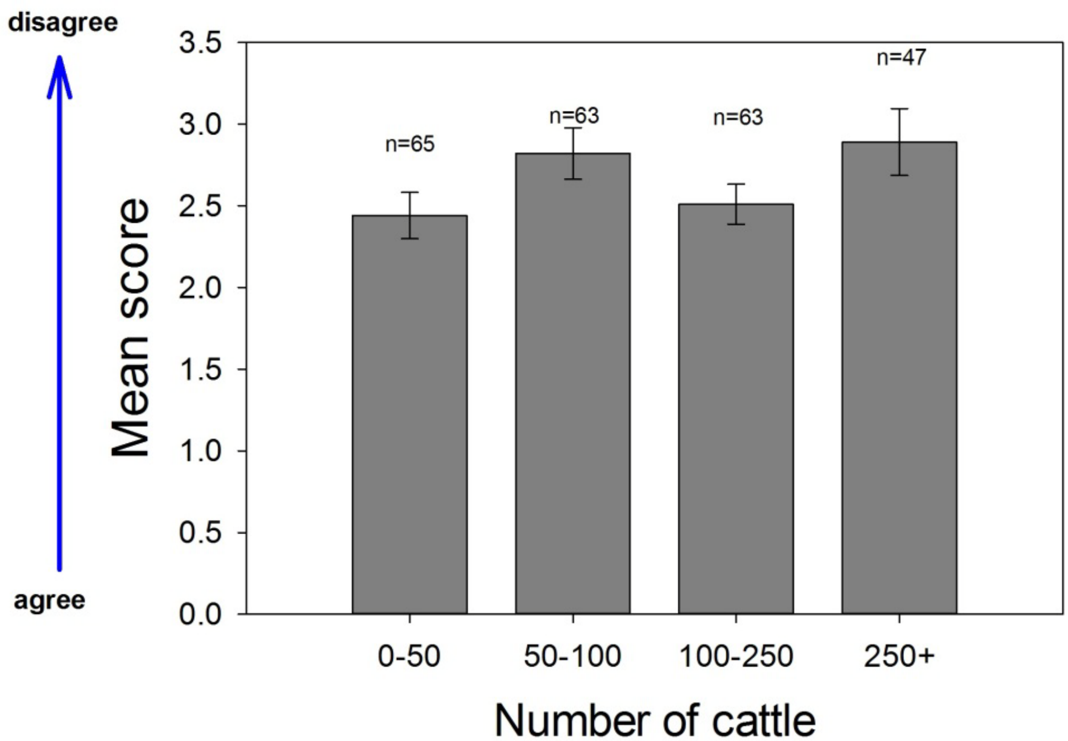


Figure 2.4-9: Differences in mean of regrouped responses to the question statement: Local climate on rangelands is changing because of global climate change. 1 = strongly agree – 5 = strongly disagree.

AVOVA indicated a significant difference in responses regarding changes in forage productivity and forage quality for operations with 0-50 and 250-500 head of cattle (Fig. 2.4-10 & 2.4-12). Regrouped analysis of responses to the same questions (changes in forage productivity and quality) indicated that no significant differences in responses regarding changes in forage productivity (p=0.118) (Fig. 2.4-11) and a significant difference in responses regarding changes in forage quality between those with 0-50 and over 250 cattle(p=0.048) (Fig. 2.4-13).

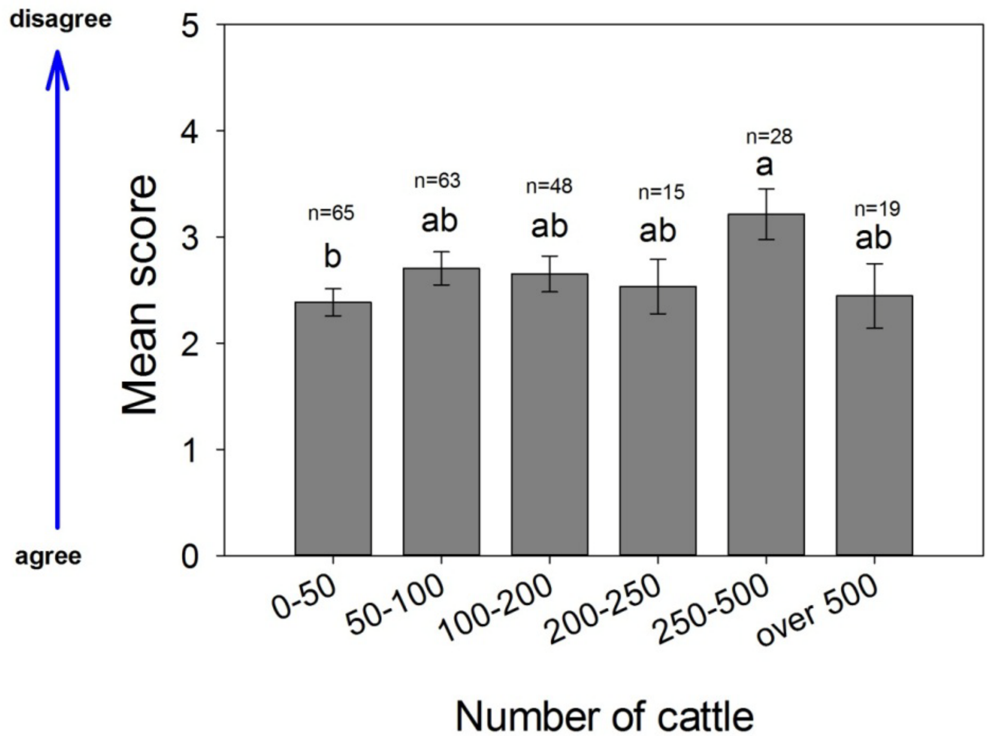


Figure 2.4-10: Differences in mean in responses to the question statement: There has been a change in forage productivity on rangelands you use because of global climate change. 1 = strongly agree – 5 = strongly disagree. (a) indicates the mean responses from those operations with between 250-500 cattle and (b) 0-50 cattle were significantly different from all other categories (ab). Error bars indicate standard error of the mean for each category.

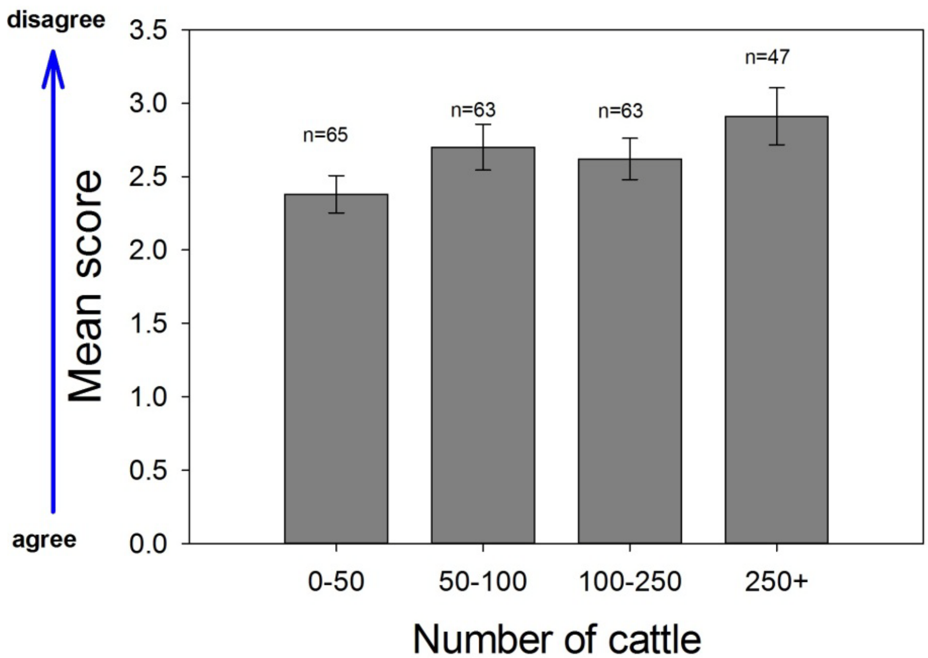


Figure 2.4-11: Differences in mean in responses to the question statement: There has been a change in forage productivity on rangelands you use because of global climate change. 1 = strongly agree – 5 = strongly disagree.

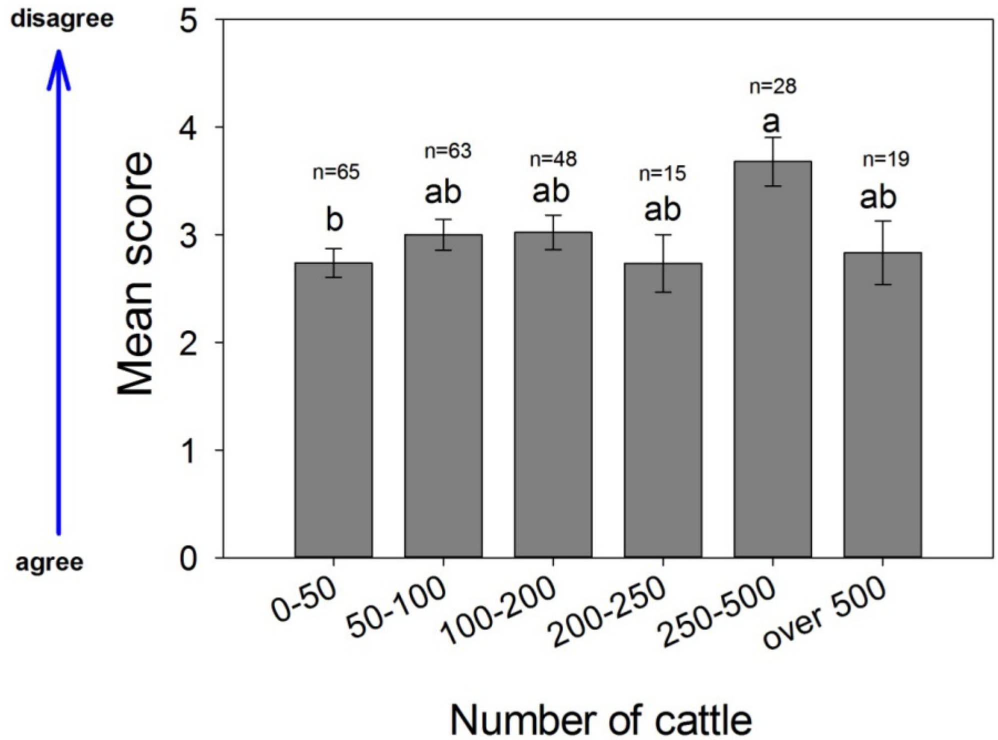


Figure 2.4-12: Differences in mean in responses to the question statement: There has been a change in forage quality on rangelands you use because of global climate change 1 = strongly agree – 5 = strongly disagree. (a) indicates the mean responses from those operations with between 250-500 cattle and (b) 0-50 cattle were significantly different from all other categories (ab). Error bars indicate standard error of the mean for each category.

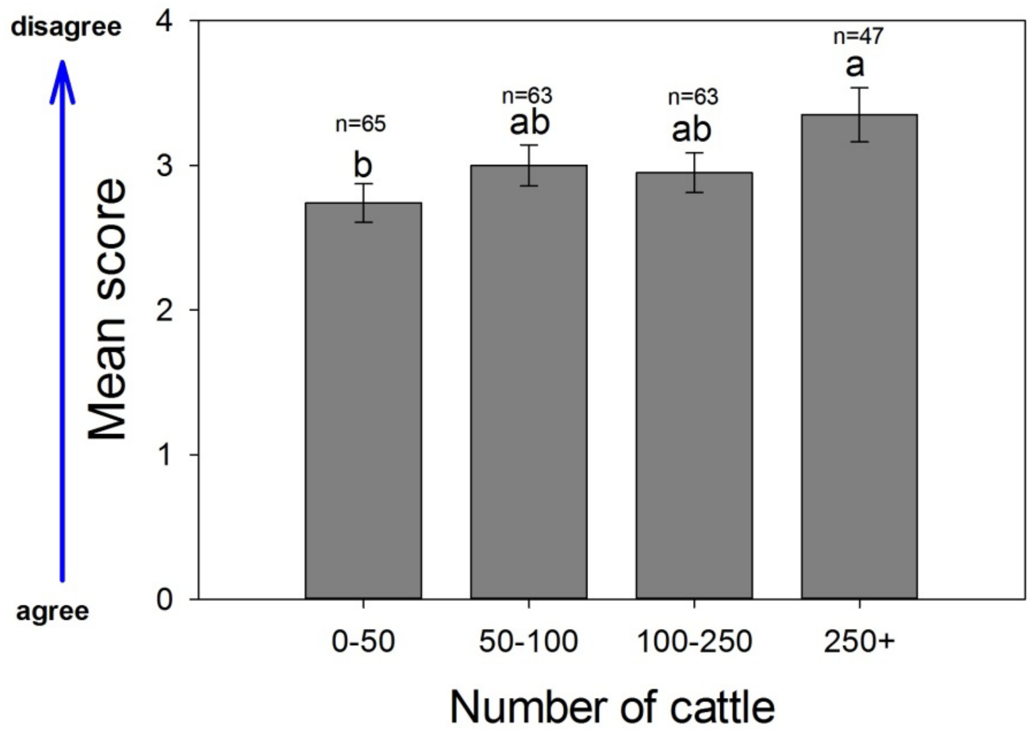


Figure 2.4-13: Differences in mean in responses to the question statement: There has been a change in forage quality on rangelands you use because of global climate change 1 = strongly agree – 5 = strongly disagree.

Multiple-response questions were analyzed using univariate analysis of variance. There was no significant main effect between region and responses to statements regarding factors commonly associated with climate change, and no significant interaction.

2.4.3 MANAGEMENT STRATEGY RESPONSES:

Further details on management changes made in response to factors associated with climate change identified in the first section of the survey were expanded upon in the second section of the survey. To try and determine if management changes were made based on changes in climate (i.e.: weather variability), we also asked more general questions excluding the term "global climate change".

Table 2.4-16: Response to question statement: "have you changed the way you manage rangelands in response to changes in climate?"

Response options	Frequency	Valid Percent	Cumulative Percent
not at all	95	40.1	40.1
slightly changed	42	17.7	57.8
moderately	53	22.4	80.2
significantly changed	37	15.6	95.8
completely changed	10	4.2	100.0
Total	237	100.0	

40% of respondents stated they have not changed the way they manage their rangelands in response to changes in climate, 40% have made slight or moderate changes, 20% completely or significantly changed management strategies (Table 2.4-16). Respondents were instructed to skip the following questions regarding economic costs associated with management changes and the extent/type of changes made if they responded "not at all" to the question: "Have you changed the way you manage rangelands in response to changes in climate?" Over 70% cited no-minimal costs in association with changes made in response to global climate change, and roughly 13% estimated a cost of $25-$50 and $50-$200 (Table 2.4-17).

Table 2.4-17: Response to question statement: "estimate the economic cost per acre associated with any management changes you have made to the way you manage any rangelands you operate on that you would associate with global climate change.

Response options	Frequency	Percent
no cost	39	27.9
0-$25	63	45.0
$25-$50	19	13.6
$50-$100	13	9.3
$100-$200	6	4.3
Total	140	100.0

Respondents were asked to identify what management changes, if any, they had made, selecting each option separately to reflect they extent of any changes made (Table 2.4-18). Regional analysis of the responses clearly depicts differences in management changes (Fig. 2.4-14). Changes identified in the "Other" category option include leasing pasture, changing to a yearling operation and operating according to the weather (i.e.: being adaptable). The most frequent management change cited by those respondents who indicated they had changed the way rangelands are managed is a seasonal change in the timing and movement of cattle/change and in the frequency of the movement of cattle. Many also reduced stocking rates/decreased operation scale. Relocating operations within or out of the province or increasing operation scale/stocking rate was found to be less common.

Table 2.4-18: Responses to question statement asking respondents to select the option that best reflected the extent of any management changes made in response to global climate change.

Category response options	Options: changes made							
	Reduced stocking rate	Seasonal change in the timing and movement of cattle	Decreased scale of operation	Relocated operation out of province	Increased stocking rate	Increased scale of operation	Relocated operation within province	Change in the frequency of the movement of cattle
Least	11	8	16	65	**71**	66	65	7
least-no	11	**13**	6	1	6	6	5	9
no change	23	18	37	**48**	43	46	45	26
no change-greatest	56	**72**	38	2	4	7	9	61
greatest	**37**	26	**37**	3	4	4	1	31
Total	138	137	134	119	128	129	125	134

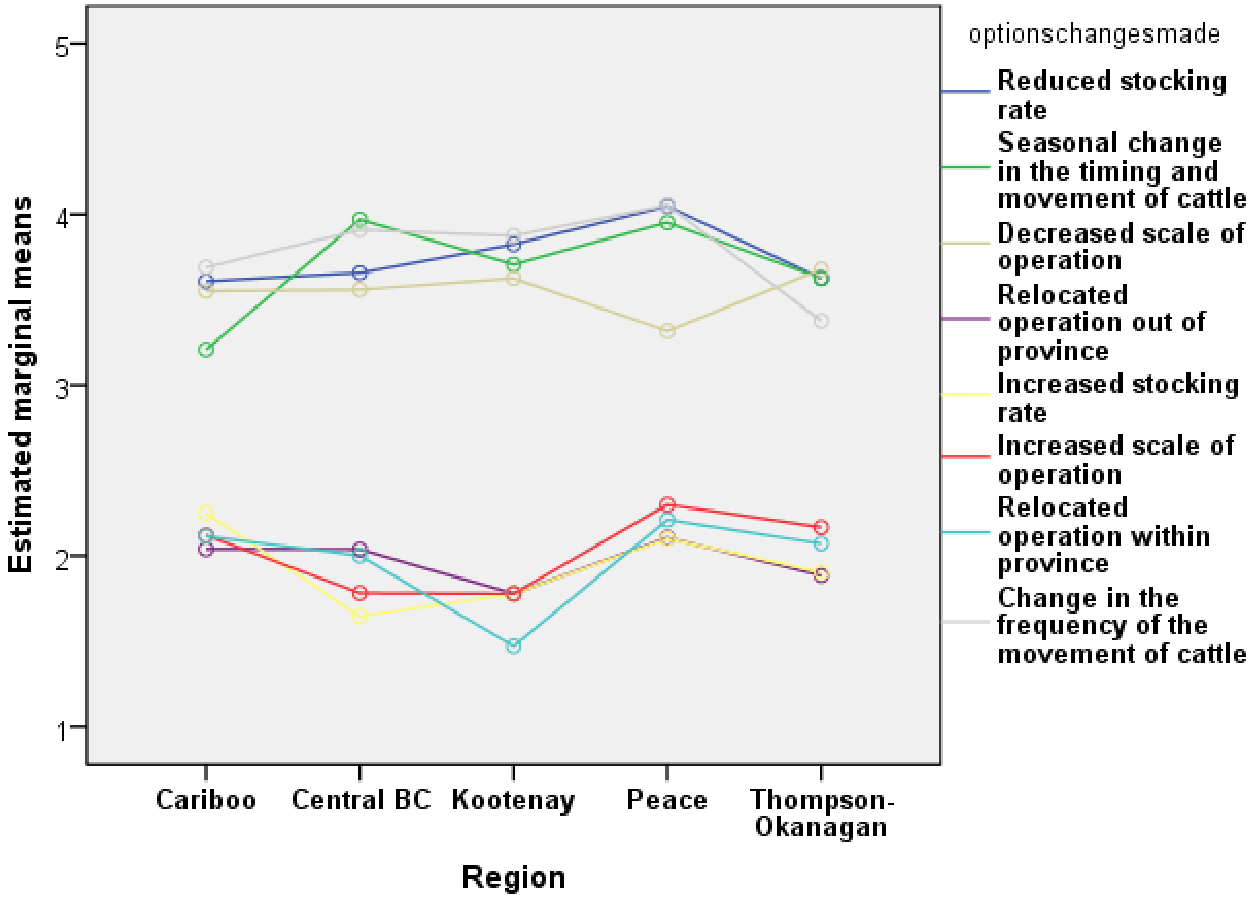


Figure 2.4-14: Difference between more frequent management changes (scale 4-5) and the less frequent (scale 1-2) according to region of British Columbia. The regional comparison illustrates differences in management strategies**.**

Individuals were asked if they had changed the way water was access/used in response to a change in the availability and/or quality of water. Category options included developing additional water sources (Table 2.4-19), sharing water sources (Table 2.4-20), trucking water in (Table 2.4-21), managing hay pastures differently (Table 2.4-22) and “other”. The following tables provide summaries of the responses to each of these categories.

Table 2.4-19: Developed additional water sources/change the way water is accessed.

Response options	Frequency	Percent
not at all	97	41.6
slightly changed	45	19.3
moderately	37	15.9
significantly changed	46	19.7
completely changed	8	3.4
Total	233	100.0

Table 2.4-20: Changed the way water is used/shared.

Response options	Frequency	Percent
not at all	169	75.1
slightly changed	18	8.0
moderately	18	8.0
significantly changed	14	6.2
completely changed	6	2.7
Total	225	100.0

Table 2.4-21: Changed the way water reaches operation (trucking water in).

Response options	Frequency	Percent
not at all	175	77.4
slightly changed	20	8.8
moderately	12	5.3
significantly changed	8	3.5
completely changed	11	4.9
Total	226	100.0

Table 2.4-22: Made irrigation/pasture management changes.

Response options	Frequency	Percent
not at all	77	33.5
slightly changed	52	22.6
moderately	48	20.9
significantly changed	34	14.8
completely changed	19	8.3
Total	230	100.0

Over 40% stated they did not develop additional water sources, 35% made slight-moderate changes and 20% significant changes and less than 5% completely changed the way water is accessed. 75% did not start sharing water sources, 16% made slight-moderate changes in sharing resources, 6% made significant changes and 3% completely changed. The majority of respondents did not make any changes in regards to trucking water in (77%), 14% made slight-moderate changes and almost 9% significantly or completely changed in regards to how water is accessed. Over 40% slightly-moderately changed the way hay pastures are managed (irrigation changes), 34% made no changes, 15% significantly changed and 8% completely changed.

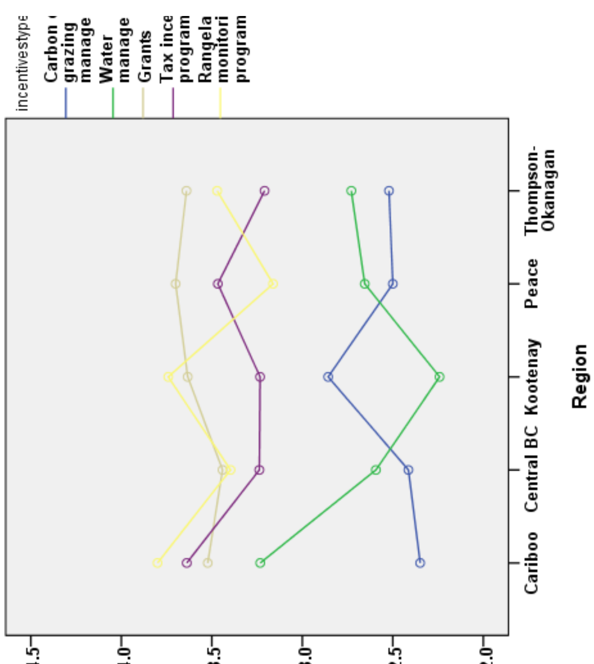
One of the goals of the survey was to determine policy tools and government programs that would best facilitate the future adaptive capacity of land managers. We asked whether respondents would like to see the provincial government design policy to address changes in management strategies on Crown land that are associated with changes in climate (Table 2.4-23).

Table 2.4-23: Response to question statement: “I would like to see provincial government design policy to address changes in management strategies on Crown land that are associated with changes in climate.”

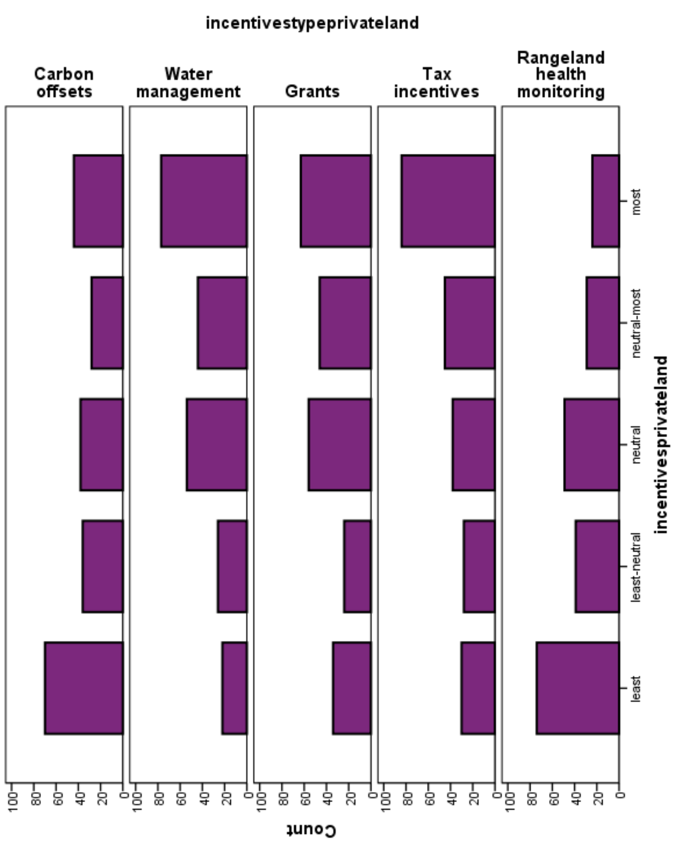
Response options	Frequency	Percent
not at all	53	22.1
somewhat	43	17.9
neutral	81	33.8
strongly	41	17.1
very strongly	22	9.2
Total	240	100.0

Most individuals were neutral (34%) as to whether they would like to see policy changes to address management changes related to variability in climate. 40% stated not at all-somewhat and over 25% stated they strongly-very strongly felt policy formation was needed.

The next two questions attempted to elucidate which incentive programs cattle ranchers would consider for managing both private and Crown land. Response options for incentive programs included carbon offsets, water management, grants, tax incentives and rangeland health monitoring (Fig. 2.4-15 & 2.4-16).



...nses regarding preferred incentives for managing private ...d health monitoring programs are least preferred to water ...ional variation in the mean responses regarding preference


incentivestypeprivateland
Carbon offsets
Water management
Grants
Tax incentives
Rangeland health monitoring
most
neutral-most
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least-neutral
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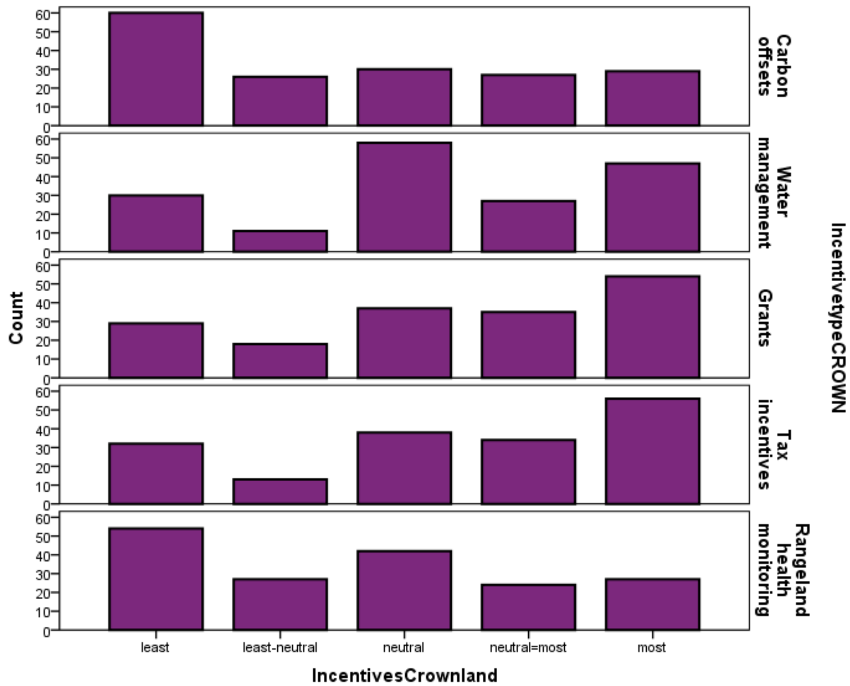

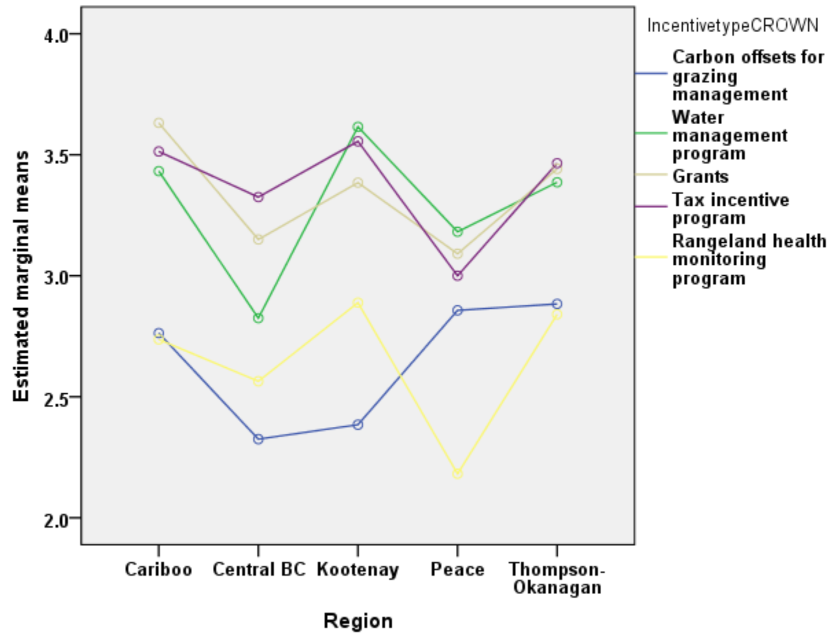

Figure 2.4-16 left & right: Note the regional variation in preferred incentives in figure 2.12 a. Carbon offset and rangeland health programs were again the least preferred option in terms of incentive programs for range management whereas grants and tax incentives were most preferred when considering the management of Crown land (n=173). Right: Regional variation in the mean responses regarding preference for different incentive programs.

A number of respondents wrote in the margins around the incentive questions, noting they were unclear as to what carbon offsets were, or were opposed to them because they felt the programs were designed to give an advantage to large industries. Figure 2.4-15 clearly shows a difference in the water management category, with respondents being more interested in these programs on their own land versus Crown land (Fig. 2.4-16). Figure 2.4-15 (right) indicates a regional difference in incentive program preference between the Cariboo and the Kootenay in terms of water management programs. Regional preference for water management, carbon offsets and rangeland health monitoring programs are depicted by the mean responses in Fig. 2.4-16 (right).

There was also a difference in terms of question response rates between private land (n=220, 91%) and Crown land (n=173, 71%). The possible reason for this is two-fold. Not all respondents access Crown land for their operations and may have felt this question did not apply to them. The second reason is based on anecdotal evidence from comments made in the returned survey regarding the ineffectiveness of government programs and unwillingness to trust that participating in these programs would be personally beneficial. Below are some selected comments representative of the sample as a whole.

> *We don't use Crown land so can't speak for those who do. Rather than incentives for global warming: guaranteed minimum price for cattle as opposed to incentives are what we need. Make environmental farm plans, verified beef programs, age verification etc. worth something.*

> *I do not believe in carbon offsets - is designed to be a money transfer and if you believe carbon should not be produced; it is still going to be produced. It is quite obvious we are in a dry trend, but this kind of thing has happened throughout history. If it continues we will need some other water development on Crown range. The thing that is costing us the most on Crown range is the filling in of clear cuts with trees, making it harder and more time consuming to find cattle when cleaning out an area of cattle.*

Government policy on addressing global climate change will have the greatest impact on the ranching industry in a negative way. I.e.: carbon offsets, cap and trade, all will increase costs with no net benefit or change to global climate change.

I intend to manage my Crown range anyway. We have been ranching in this location since 1920 and raising cattle for approximately 80 years. Throughout this time there have been dry spells, wet spells, grasshopper plagues and severe weather.

Regional analysis of potential policy preferences in terms of management on Crown and private land garnered some interesting results. A two-way analysis of variance indicated a regional difference in terms of preferred incentive for managing Crown land, but the interaction effect was not significant. Post hoc analysis indicated no significant regional difference. No significant regional difference was observed in terms of incentives for managing private land (Table 2.4-24).

Table 2.4-24: Two-way ANOVA regional analysis of incentives of potential policy preferences in terms of management on Crown land.

Dependent Variable: IncentivesCrownland

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	137.480[a]	24	5.728	2.708	.000
Intercept	7402.814	1	7402.814	3499.092	.000
Region	22.967	4	5.742	2.714	.029
IncentivetypeCROWN	92.091	4	23.023	10.882	.000
Region * IncentivetypeCROWN	17.070	16	1.067	.504	.946
Error	1734.823	820	2.116		
Total	9860.000	845			
Corrected Total	1872.303	844			

a. R Squared = .073 (Adjusted R Squared = .046)

Regional analysis was also performed to investigate whether there was a difference in responses to questions regarding economic costs associated with management changes respondents made that they attributed to climate change. Results of one-way analysis of variance indicated no significant regional difference in responses to this question. There was a significant regional difference in terms of the biggest challenges currently facing operations (Table 2.4-25).

Table 2.4-25: Two-way ANOVA testing main effect between region and question asking individuals to identify the major challenges currently facing operations.

Dependent Variable: challenge response

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1223.292[a]	41	29.836	21.896	.000	.399
Intercept	4226.800	1	4226.800	3101.864	.000	.696
Region	25.219	6	4.203	3.085	.005*	.013*
biggest challenge	349.187	5	69.837	51.251	.000	.159
Region * biggest challenge	54.359	30	1.812	1.330	.110	.029*
Error	1846.410	1355	1.363			
Total	19859.000	1397				
Corrected Total	3069.702	1396				

a. R Squared = .399 (Adjusted R Squared = .380)

2.4.4 INFORMATION NEEDS & PREFERENCES

In terms of information needs, when asked if they would benefit from a better understanding of what global climate change is, 38% felt they would not benefit, 38% felt they would somewhat benefit, 24% felt they would significantly benefit (Table 2.4-26). Of those identifying an interest in further information, the majority preferred mailed educational material with a website being the second choice. No significant difference was found in a regional analysis of responses regarding future information needs.

Table 2.4-26: Response to question statement: "I would benefit from a better understanding of what global climate change is and how it could impact my region."

Response options	Frequency	Valid Percent	Cumulative Percent
not at all	52	22.0	22.0
not at all - somewhat	38	16.1	38.1
somewhat	90	38.1	76.3
somewhat-significantly benefit	28	11.9	88.1
significantly benefit	28	11.9	100.0
Total	236	100.0	

2.4.5 Respondent comments

The final page of the survey provided a space to accommodate any additional comments regarding the effects of global climate change on the ranching industry. Almost half (49%) of respondents took advantage of the opportunity to provide input and feedback. Additional comments made in the margins of the returned surveys were grouped with the final comment section as all pertained to perspectives about global climate change and the ranching industry. A select sample of these comments is provided here, however a verbatim transcription of all comments can be found in Appendix V. The anecdotal information provided via the comments is interesting as it clearly encapsulates a divided opinion regarding climate change within the BC cattle ranching industry.

There is a global climate change, no doubt, how much is really man-made? Petty prices for cattle and some appreciated (financial help?) for ranchers would help more than anything else. If a government wants cheap food for all, it must support the producer. The producer is the key for quality of food and environment and life.

I don't believe global warming has affected climate change. In the winter of 1930-31 there was no snow; it was a reasonably mild winter. The winter of 1942-43 there was hardly any snow and a very early spring. There has been winter when we haven't had snow until the end of December and been winters when we've had snow in October Through the years there has been wet years and dry years. I don't think things have changed.

The so called climate change is just a cycle that has not been seen or recorded before. To let government to be involved is going to allow another type of beating stick to use on food producers. It is trumped up hype to allow big business to gain another way of making money for themselves. As for carbon credits, this is a joke - big corporations are allowed to buy credit from someone else and not correct their own pollution.

Global warming started when the ice age stopped.

Global climate change is a hoax!

I believe that any policy change should come from people involved in the industry (such as BCCA) and not the government. I perceive the government to have a biased and limited knowledge of this problem.

2.5 DISCUSSION

The majority of respondents believe global climate change is occurring and is affecting their livelihoods; however there is a need for further education about theories such as the greenhouse effect, global warming and climate change. A large number of surveys were returned with comments revealing a need for clarity concerning these concepts. It is critical that effective future range management approaches include the communication and education of important environmental concepts. Illumination of the meaning of each concept and how they are interrelated factors and not separate entities or “catch phrases” of the time or scientific “fads” is essential for future adaptive capacity.

The following survey comment provides an example of this misperception:

> *Global climate change has been occurring for the last 5 000 000 years. You can't get the weather right three days in advance. What makes you think you know what it's going to be like in the next month much less ten years from now? What happened to global warming?*

The tendency for climate change to be referred to as either global warming or described in terms of changes in weather patterns was also identified by Reid et al. (2007) in their study focusing on vulnerability and adaptation to climate change in agricultural operations in Ontario. They found only seventeen percent associated climate change specifically with a change in variability and extremes, and those respondents also expressed the greatest degree of concern for climate change. In a survey of 622 individuals about perceived environmental, ecological or societal impacts form climate change in the U.S. by Semenza et al. (2011), heat waves, average temperature increase, flooding and more frequent storms were identified by 80-90% of respondents. In my study, the two most common factors respondents associated with global climate change were changes in annual precipitation and temperature, followed closely by a change in frequency of severe weather events.

Based on respondent comments, a significant proportion of respondents in my study made it clear they believe global climate change is a natural cycle, even if they did acknowledge the fact that it is occurring. The influence of human activity on the perceived natural cycles was not entirely discounted, nor was it seen as the main or even a significant causal factor. Borick et al. (2011) also found that of those Canadians who believed in global warming, division between attribution to anthropogenic or natural causes. Reid et al. (2007) found 21% of producers were skeptical about the issue, maintaining the changes were due to natural cycles. As Antle (1996) points out, this may be because when climate is stable, historical records can be interpreted as static processes but when the climate is changing those distributions become nonstationary. Climate changes caused by an accumulation of greenhouse gases are at a slower, imperceptible pace to farmers and small annual changes would be of little consequence relative to normal climatic variation. Many range managers may not attribute management changes to annual variability in temperature and precipitation, but these changes equate to climate change adaptation. Adaptations are made to the yearly variability, and long-term average conditions, including extremes.

The finding that establishment time appears to influence whether operators believe human activities are increasing the rate of global climate change supports this idea. Cattle ranchers operating for less than 20 years were more likely to agree with the statement that human activity increases the rate at which global climate changes occur in comparison to those operating for more than 40 years. This may be a reflection of the fact that the concept of climate change has gained more public acceptance in the past two decades and would likely be perceived as a legitimate risk to an operation by those in this category in comparison to those who have been operating for a long period of time and tend to rely on experiential or embedded knowledge.

Knapp & Fernandez-Gimenez (2009) studied how ranchers in Colorado gain knowledge and how this information is shared. They found that ranchers consistently relied on embedded and experiential knowledge to inform management decisions. They define embedded knowledge as that which “comes from living on the land and observing natural processes.” They state that this knowledge often includes a limited understanding of “cycles that are longer than a human lifetime, such as erosion processes, changes in hydrology, climate change, and ecosystem resilience.” Although their participants perceived an extended drought period, they were divided whether it was a result of climate change or part of a natural, cyclical process. Maddison (2007) noted that the most important finding was that although experienced farmers were more likely to perceive climate change, it was educated farmers that were more likely to make one change to adapt to it.

Operation establishment did not appear to influence any other perceptions about climate change. Based on this, I conclude that length of time of cattle ranching does not significantly influence belief in or understanding of what climate change is, but affects the perception regarding the influence that human activities have on the overall rate at which global climate change occurs. Regional differences were observed in this perception between the Peace and Thompson-Okanagan regions with producers in the Thompson-Okanagan being more likely to agree that human activities are influencing the rate at which global climate changes occur. Further demographic information regarding age, income and education level etc., would be required to determine why this difference exists.

Interestingly, operation scale in terms of head of cattle appears to influence perceptions of localized climate variation on rangelands due to global climate change and changes in forage productivity and quality on a regional scale. Without further demographic information such as revenue, number of employees, operation diversification or educational attainment, it is difficult to determine conclusively what may be driving these observations. However, it is likely that larger operations, (250-500 head of cattle) are more focused on economic factors that will affect the vulnerability of their operations whereas smaller operations with 0-50 cattle are more sensitive to changes in forage quality and availability. Larger operations often grow their forage crops for silage and feed and do not rely as much on accessing natural grazing areas.

According to the BC Ministry of Agriculture the average feedlot has 400 head of cattle, with many using grain for feed and not grazing land. Smaller operations, relying more heavily on available range areas for natural forage are more vulnerable to variability and availability. Larger operations (100 head and over) have per beef cow investment of $9000-$12,000, whereas smaller operations (below 100 head) have per head investment of greater than

$15,000 (Henry 2003), meaning that livelihoods have the potential to be severely impacted by fluctuations in forage quality and quantity.

While it can be difficult to determine whether management changes are made in response to normal climate variability or the longer-term impacts of climate change, general adaptation strategies that would vary according to local conditions and farming strategies can be summarized as follows (Dolan et al. 2001; Howden et al.2007; IPCC 2007; AAFC 2010):

- changing the timing of operations such as planting and harvesting
- changing the timing of inputs such as irrigation and fertilization
- altering tillage, crop selection or diversifying operations (forage and livestock)
- changing size and scale of operations by re-locating, ceasing operations in some locations, increasing or decreasing number of livestock
- modifying stocking rates and timing of grazing to match pasture conditions
- expanding financial security via crop insurance, bank loans or available government programs

Managing for changes in the ability of available forage was identified by respondents as a management change made in response to change in climate with almost sixty percent indicating they had made some type of management change. This finding is in contrast to only fifteen percent of 120 southwestern Ontario farm operators surveyed by Smit et al. over five years (1996). Of these operations, changes or diversification of crop and/or enterprise was frequent. Some operators expanded or reduced the size of their operation, adopted new technology or altered the amount or type of inputs such as feed or fertilizers. We found similar adaptation strategies by BC cattle ranchers with the most frequent management change being a change in the timing and movement of cattle and a change and in the frequency of movement. Many also reduced stocking rates/decreased operation scale. These strategies were also found by Crawford & McNair (2012) in their survey of adaptation strategies by cattle ranchers in Central BC.

Regional analysis provided some areas of potential focus for programs that would assist producers in further adapting to changes in climate. Range managers in the Peace and Cariboo regions would likely benefit from a program or a government-supported management program focused on developing and maintaining access to sustainable sources of water. Producers in these areas were much more likely to agree with the statement that access to and availability of water has decreased as a result of global climate change in comparison to respondents in the Thompson-Okanagan region. This may be a reflection of the fact the linear trend of increasing global temperatures is greater at northern latitudes (IPCC, 2007). So although warmer temperatures in the Peace might mean milder winters and longer growing seasons, it also means a greater demand on existing water supplies. This conclusion is supported by the findings of Crawford & McNair (2012) who state "access to water and future water supply is of substantial concern for cattle producers in the interior."

My findings also suggest that the Peace, Cariboo and Kootenay regions would likely benefit from programs focused on mitigating the destruction of forests caused by the mountain pine beetle. Such programs should consider including funding for fencing, reforestation or harvesting. Crawford & McNair (2012) found that producers in Central BC have been significantly impacted by changes in landscape and management practices in response to the mountain pine beetle. Producers there noted altered patterns of hydrology have been impacted by beetle kill and tree removal. These concerns were also shared by producers in the Peace and Kootenay regions.

Other adaptive strategies include market-based policy options including carbon taxes and cap-and-trade energy policy. Borick et al. (2011) found the majority of Canadians surveyed in their study indicated support of a cap and trade energy policy, even if there was a monthly cost implied. Most Americans opposed cap and trade and carbon tax policy programs in any of the forms presented (i.e.: with and without individual costs). This study indicated little support for carbon offsets for range management practices on either Crown or private land. However, much of this opposition may be due to a lack of understanding of the programs and the general view that the programs are designed to benefit large industry and not private business owners.

Further research into the perception of these two policy options would be valuable in informing and implementing effective climate change policy. This would be a valuable endeavor as close to sixty percent of those surveyed hold Crown grazing tenures. As up to 95% of land used for grazing cattle is Crown-tenured, it is important to determine the degree of investment cattle ranchers have in maintaining the health of Crown-tenured rangeland and possible options for incentive programs such as carbon offsets.

Anecdotal information gathered from the open comments section offered further insight to the perspectives and experiences of BC cattle ranchers. There is an overall sense of frustration with lack of government policy and programming to address the changing needs of the industry. This illustrates that the sensitivity of systems and relative adaptations are not just to climate, but to social, economic and ecological systems. Ongoing evolution of responses and adaptations and policy responses need to exhibit the same flexibility (Smit et al. 2000). Key areas of focus should include the development of strategies for wildlife management, water storage and management, restoration programs for areas affected by the mountain pine beetle (Drolet 2012; Crawford & McNair 2012) and logging and agroforestry programs.

Formation of a collaborative learning process to support livestock producers will enable the adaptive capacity of producers (Fig. 2.5-1) (Thornton et al. 2007; Crawford & McNair 2012) and informed decision-making, providing a broader long-term framework for range management planning. The information will be made accessible in ways most desired by the survey respondents and distributed by Thompson Rivers University and the BC Cattlemen’s Association. Some of the areas of focus for further education and information identified via survey responses include the distinction between climate change, global warming, weather patterns (local climate) and regional variations in relation to climate change, and carbon tax/carbon storage credits.

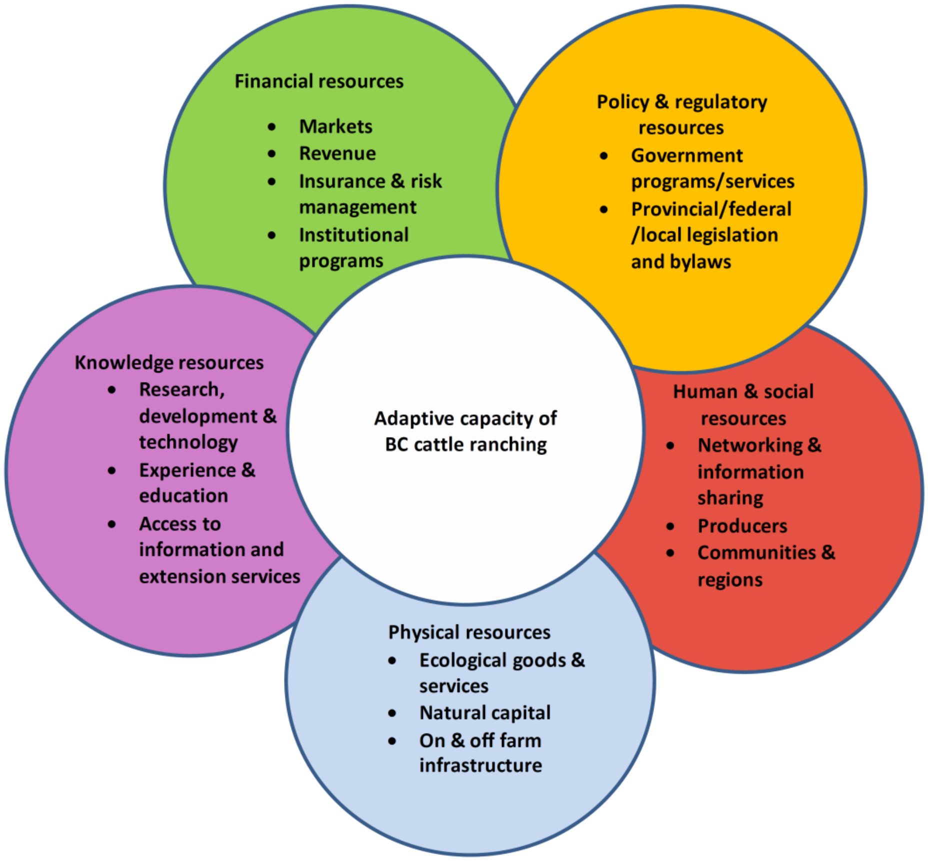

Figure 2.5-1: Graphic representation of the resources available for building adaptive capacity for the BC cattle ranching industry (adapted from Crawford & McNair 2012).

The phrase "climate change" is politically charged and consequently has perhaps lost appeal with the ranching community demographic. Perhaps a more generic, or neutral term could be developed in order to facilitate future discussions. Movement towards building adaptive capacity must include the cooperative effort and support of members of the ranching community, local government (municipalities and regional districts and communities, and the provincial and federal government. Such a collaborative effort, including experiential and scientific knowledge will be crucial to reducing the vulnerability of this sector and building adaptive capacity.

3. Conclusions & Future Directions

Establishing the capacity to adapt to changing environments and creating management plans reflective of this capacity will be critical in aiding ranchers to inform local and provincial governments of their needs. It will also help governments and local planners to form policy and long-term plans illustrative of both the regional and larger-scale needs of the cattle ranching industry.

Reducing vulnerability is a large component of enabling this capacity and needs to include the development and implementation of educational tools to illuminate complex and abstract concepts such as global climate change. The framework for these tools should be based on communication strategies that draw upon people's experiences and local knowledge of the environment (Ruddell et al. 2011; Crawford & McNair 2012). As Walker & Sydneysmith (2008) suggest, delivering information in a manner that resonates with the issues and concerns of those receiving it—those directly responsible for implementing adaptation—is crucial.

The vulnerability of the beef cattle industry and agricultural producers will continue to increase in relation to increasing climate variability on a provincial, national and global scale. Creating an open dialogue to facilitate management strategies that will enable the capacity of producers to adapt to global climate change will be crucial in addressing future food security issues. The beef cattle industry in BC has the opportunity to lead by example and create the framework for this process, providing a template for producers in all areas of the agricultural sector.

Thorpe (2012) provides a comprehensive overview of recommended adaptations to climate change in grassland management for the management of prairie ecosystems but these can be applied to BC grazing systems. Just as the effects of climate change extend beyond local or regional scales, adaptation strategies must do the same. To be effective, strategies should tie into efforts on a national and even global level. Continuous improvements in technology will precipitate this process and the ability to observe and predict climate changes. Brown & Thorpe (2008) provide an example of technology contributing to our knowledge of how the local effects of climate change can have global impacts. They state that reduced precipitation and increased temperatures “can lead to overgrazing, which can cascade into regional desertification [which can] cause increased wind erosion and dust that can be transported by upper atmospheric winds where it can affect global weather patterns and impact human health.”

However, research and technology alone will be ineffective without a thorough understanding of the decision-making environment (Stuth et al. 1991) and the capacity to effect change. Local knowledge, experience and skills in dealing with climate variability and assessing risk provide invaluable information to future planning efforts. Advances in technology will allow for more accurate climate predictions to enhance and develop adaptive capacity and incorporate different communication and education tools (IPCC 2007; Brown & Thorpe 2008). As Thornton et al. (2007) state, the first step is assessing adaptation options in grazing systems that reduce vulnerability to people and the environment with the overall goal of “maintaining or increasing food security, incomes and resilience while maintaining key ecosystem functions.” They make the important distinction that capacity-building efforts need to focus on helping producers deal with changes and variability that extend well beyond their current knowledge and experience. The IPCC (2007) cite numerous examples where “social capital, social networks, values, perceptions, customs, traditions and levels of cognition affect the capability of communities to adapt to risks related to climate change.”

Thorpe (2012) identified short, medium and long-term management options for grazing systems. Most short-term options are examples of reactive adaptation, in response to extreme weather events. Medium-term options include more conservative approaches to stocking rates, grazing and water management. Long-term options include revisions of range management programs, policies and approaches, and more consistent grassland monitoring. There are many programs, existing and in development, that have the potential to provide the framework for this capacity-building process, both short and long-term. Table 3.0-1 lists program options currently available to BC cattle ranchers and agricultural planners at various levels of government and scope.

The two programs with perhaps the most potential are the federal Agri-Foresight program—a tool designed identify potential future risks and develop strategies to manage them and to take advantage of anticipated opportunities, and the BC Agriculture & Food Climate Action Initiative. Knowledge and education continue to be the most powerful and enabling tools in moving towards reducing vulnerability and building capacity. Second to education, effective governance is a key mechanism for change. Locally, municipal and regional governments need to consider the effects of climate change in community planning. At the provincial level, the Agricultural Land Reserve (ALR) (Walker & Sydneysmith 2008) and stakeholder groups such as the BCCA will be the most effective and powerful tool in working with various levels of government to both inform policy and promote adaptive management practices—especially those pertaining to water management.

Table 3.0-1: Program options for building adaptive capacity for BC cattle ranchers.

Agency	Program options
Federal government (Agriculture Agri-Food Canada internal programs)	– The Sustainable Agriculture Environmental Systems (SAGES) initiative: producers benefit through development and availability of new and improved agricultural practices that address environmental challenges such as climate variability and crop, livestock, and water management in an economically sustainable manner. – National Agri-Environmental Health Analysis and Reporting Program (NAHARP): provide science-based agri-environmental information that may guide policy decisions.
Regional/municipal/provincial government level	– Canadian Agricultural Adaptation Program (CAAP): program with the objective of facilitating the agriculture, agri-food, and agri-based products sector's ability to seize opportunities; respond to new and emerging issues and pilot solutions. – AgriInsurance (production insurance) – AgriInvest – AgriRecovery – AgriStability – The BC Agriculture & Food Climate Action Initiative: results of project will be applied to the On-Farm Adaptation Practices project and the Regional Agricultural Adaptation Strategies project. – Agri-Geomatics programs and information systems
Provincial	– BC Agri-Environmental Risk Assessment (EFPs)/On-Farm Sustainable Agricultural Practices (BMPs).
Industrial cattle-ranching operations	– AgriStability provides support when the current year program margin falls below 85% of reference margin. – Canadian Agricultural Adaptation Program (CAAP): objective of facilitating the agriculture, agri-food, and agri-based products sector's ability to seize opportunities, respond to new and emerging issues and pilot solutions.
All levels/agencies	– Agri-Foresight (federal program): tool to help identify potential future risks and develop strategies to manage them and to take advantage of anticipated opportunities.
Producers/landowners	– Prairie Shelterbelt Program (Peace River region) – Community Pasture Program – AgriStability provides support when the current year program margin falls below 85% of reference margin.

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5. Appendices

5.1 Appendix I

Cattle inventories, by province				Cattle inventories, by province		
(British Columbia)				**(Canada)**		
	As of January 1,	**As of July 1,**			**As of January 1,**	**As of July 1,**
	2012	**2011**			**2012**	**2011**
	thousand head				**thousand head**	
B.C.				**Canada**		
Cattle	**540**	**650**		**Cattle**	**12,515.00**	**13,870.00**
Bulls	12	13		Bulls	221.2	235.3
Milk cows	71.5	72		Milk cows	985.3	982
Beef cows	195	193		Beef cows	4,228.40	4,201.80
Dairy heifers	36	35		Dairy heifers	444.1	447.3
Beef heifers	42	58.3		Beef heifers	1,393.80	1,784.00
Beef heifers for breeding	31.5	33		Beef heifers for breeding	554.3	662.2
Beef heifers for market	10.5	25.3		Beef heifers for market	839.5	1,121.80
Steers	25	50		Steers	1,098.10	1,472.10

Calves	158.5	228.7		Calves	4,144.10	4,747.50
Notes:				**Notes:**		
- **Bull:** An uncastrated male bovine				- **Bull:** An uncastrated male bovine		
- **Heifer:** Female cow that has never borne young				- **Heifer:** Female cow that has never borne young		
- **Steer:** A castrated male bovine				- **Steer:** A castrated male bovine		
Source: Statistics Canada, CANSIM, table 003-0032 and Catalogue no. 23-012-X (free).				**Source:** Statistics Canada, CANSIM, table 003-0032 and Catalogue no. 23-012-X (free).		
Last modified: 2012-02-20.				Last modified: 2012-02-20.		

5.2 Appendix II

«AddressBlock» <<DATE>>

Dear «GreetingLine»,

In a few days you will receive a request to fill out a brief survey for an important research project being conducted by Thompson Rivers University in partnership with the BC Cattlemen's Association. All BCCA members across BC will be receiving a survey in the mail shortly after receiving this letter.

The survey aim is to find out if global climate change is having an impact on cattle ranching operations in BC.

I am writing in advance to let you know ahead of time that you will be contacted for this purpose. The study is an important one that will help the BCCA work towards creating management strategies that address provincial and regional variations in climate that are predicted to occur.

Thank you for your time and consideration. Your support of this project is important and appreciated.

Sincerely,

Mercedes Cox

MSc Environmental Science Candidate

5.3 Appendix III

Results from this voluntary survey will be used to help the BC Cattlemen's Association and the provincial government to develop range management strategies that take into account regional climate variations and fluctuations related to global climate change. Through understanding what cattle ranchers are experiencing, management plans can be tailored to specific regional needs and concerns. This will lead to the development of more effective management strategies. We need to know what cattle producers think about global warming caused by global climate change and how these changes may be affecting cattle ranching operations.

As an added incentive, those who complete the survey will be entered to win one of three prizes. Participants will be eligible to win a credit at their local farm supply store. There is one $100.00 prize and two $50.00 prizes available to be won!

Your answers are completely confidential and will be released only as summaries in which no individual's answers can be identified. Completion of the questionnaire will indicate consent for involvement in this project.

Section 1: Global Climate Change Questions

1. Do you think human activities are increasing the rate at which global climate changes occur? Please select the extent to which you agree with the following statement. ***With 1 being strongly agree and 5 strongly disagree*.**

	1	2	3	4	5
	(strongly agree)	**(somewhat agree)**	**(neutral)**	**(somewhat disagree)**	**(strongly disagree)**
Human activities are increasing rate of global climate change					

2. The following is a list of factors commonly associated with global climate change. Please select the extent to which you agree with each of the following statements. ***Choose each option separately with 1 being strongly agree and 5 strongly disagree.***

	1	2	3	4	5
	(strongly agree)	**(somewhat agree)**	**(neutral)**	**(somewhat disagree)**	**(strongly disagree)**
Change in annual precipitation					
Change in annual temperature					
Change in length and timing of seasons					
Change in the frequency of severe weather events					
Other (please identify) ________					

3. Please choose the extent to which you agree with the following statement: Local climate on rangelands is changing because of global climate change. ***With 1 being strongly agree and 5 strongly disagree*.**

	1	2	3	4	5
	(strongly agree)	**(somewhat agree)**	**(neutral)**	**(somewhat disagree)**	**(strongly disagree)**
Local climate on rangelands is changing because of global climate change					

4. Please choose the extent to which you agree with the following statement: There has been a change in forage productivity on rangelands you use because of regional climate change. ***With 1 being strongly agree and 5 strongly disagree.***

	1	2	3	4	5
	(strongly agree)	**(somewhat agree)**	**(neutral)**	**(somewhat disagree)**	**(strongly disagree)**
Change in **forage productivity** on rangelands you use because of					

regional climate change.					

5. Please choose the extent to which you agree with the following statement: There has been a change in <u>forage quality</u> on rangelands you use because of regional climate change. ***With 1 being strongly agree and 5 strongly disagree.***

	1	2	3	4	5
	(strongly agree)	**(somewhat agree)**	**(neutral)**	**(somewhat disagree)**	**(strongly disagree)**
Change in **forage quality** on rangelands you use because of regional climate change.					

6. Please choose the option that most closely reflects your agreement with the following statement: Access and availability to water has decreased as a result of regional climate change. ***With 1 being strongly agree and 5 being strongly disagree.***

	1	2	3	4	5
	(strongly agree)	**(somewhat agree)**	**(neutral)**	**(somewhat disagree)**	**(strongly disagree)**
Access and availability to water has decreased as a result of regional climate change.					

7. Please choose the option that most closely reflects your agreement with the following statement: The destruction of forests caused by the pine beetle has impacted my ranching operation. With 1 being very positively and 5 being very negatively.

	1	2	3	4	5
	(very positively)	**(positively)**	**(neutral)**	**(negatively)**	**(very negatively)**
Mountain pine beetle					

Section 2: Range Management Strategies & Global Climate Change

1. Please select the option that best reflects the extent to which you agree with each of the following statements about the availability of and/or quality of water. ***Select each option separately with 1 being not at all and 5 completely changed.***

	1	**2**	**3**	**4**	**5**
	(not at all)	**(slightly changed)**	**(moderately)**	**(significantly changed)**	**(completely changed)**
Developed additional water sources					
Shared water sources					
Trucked water in					
Managed hay pastures differently					
Other (please identify) __________					

2. Please select the extent to which you agree with the following statement: I would like to see the provincial government design policy to address changes in management strategies on Crown land that are associated with changes in climate. ***With 1 being not at all and 5 very strongly.***

	1	**2**	**3**	**4**	**5**
	(not at all)	**(somewhat)**	**(neutral)**	**(strongly)**	**(very strongly)**
Government climate change policy					

3. Please select the option which most closely reflects your answer to the following question: Have you changed the way you manage rangelands in response to changes in climate? ***With 1 being not at all and 5 completely changed.***

	1	**2**	**3**	**4**	**5**

	(not at all)	(slightly changed)	(moderately)	(significantly changed)	(completely changed)
Management change					

If so, please briefly explain what changes you have made:

____

****If you selected <u>(not at all)</u> skip to Question 6.****

4. Please select the option that best estimates the economic cost per hectare associated with any management changes you have made that you would associate with global climate change.

	1	2	3	4	5
	(no cost)	($0-$25)	($25-$50)	($50-$100)	($100-$200)
Management cost per hectare					

5. If you have changed the way you manage your rangelands, please select the possible changes in relation to the extent of each change. ***Select each option separately with 1 being the least change and 5 being the greatest change.***

		1	**2**	**3**	**4**	**5**
		(least)		**(no change)**		**(greatest)**
i.	Reduced stocking rate					
ii.	Seasonal change in the timing of movement of cattle					
iii.	Decreased scale of operation					
iv.	Relocated operation out of province					
v.	Increased stocking rate					
vi.	Increased scale of operation					
vii.	Relocated operation within province					
viii.	Change in the frequency of the movement of cattle					
ix.	Other (please explain) _________________					

6. Please identify what types of incentives you would consider in exchange for sustainably managing <u>private</u> rangelands you use. ***Rank the options listed below in the order of most important to least important with 1 being least important.***

	1 **(least)**	**2**	**3**	**4**	**5** **(most)**
Carbon offsets for grazing management					
Water management					

Grants					
Tax incentive program					
Rangeland health monitoring program					

7. Please identify what types of incentives you would consider in exchange for sustainably managing <u>Crown</u> rangelands you use. ***Select the options listed below in the order of least important to most important with 1 being least important.***

	1 **(least)**	**2**	**3**	**4**	**5** **(most)**
Carbon offsets for grazing management					
Water management					
Grants					
Tax incentive program					
Rangeland health monitoring program					

Section 3: Background Questions

1. What region of the province do you currently operate a cattle ranch? ***Check more than one if applicable.***

____ South Coast	____ Central BC
____ Thompson-Okanagan	____ Cariboo
____ Kootenay	____ Peace

2. What is the nearest community to you? ______________________________

3. How long has your ranch been operating at your current location?

___ Less than 5 years	___ 6-10 years	___ 11-15 years
___ 16 –20 years	___ 21-25 years	___ 26 –30 years
___ 31-35 years	___ 36-40 years	___ More than 40 years (please state time)

4. Approximately what amount of your ranching operation falls into each of the following land ownership categories? *Write in the estimated acreage.*

Private ____	Crown (provincial) land ____
Common/shared pasture ____	Private lease ____

5. How many head of cattle do you manage on the land your ranch currently operates on?

___ 0-50	___ 50-100	___ 100-200
___ 200-250	___ 250-500	___ over 500

6. If you hold a Crown tenure, please estimate on a scale of 1-5, with 1 being low investment and 5 being high, how much effort are you willing to invest in maintaining the health of the Crown tenured land?

	1 (low)	**2**	**3**	**4**	**5 (high)**
Crown tenure land investment					

7. **What are the major challenges currently facing your ranching operation? *Rank each by the level of significance to you with 1 being least significant.***

		1 (least significant)	2	3	4	5 (most significant)
i.	Cattle Prices					
ii.	Fuel Costs					
iii.	Global Climate Change					
iv.	Water Availability					
v.	Grain/Hay Costs					
vi.	Family involvement /successional planning					

8. Is your operation strictly cattle ranching or do you also engage in agricultural or crop producing activities? If so, please list the scale of your other operations and what type of crops you grow.

ACTIVITY & SCALE (# OF HECTARES):____

SECTION 4: INFORMATION NEEDS & PREFERENCES

1. Please choose the extent to which you agree with the following statement: I would benefit from a better understanding of what global climate change is. *With 1 being not at all and 5 very strongly.*

	1 (not at all)	2	3 (somewhat)	4	5 (significantly benefit)
Access to information about climate change					

2. If you think you would benefit from additional information about global climate change, how would you prefer to access this information? *Please select in order of preference with 1 being most preferred to 6 being least.*

____ Mailed reading material	____ Video/DVD

____ Emailed material	____ Website
____ Informational workshop	____ Other (please explain) ____________

3. Please share any other thoughts or comments regarding the effects of global climate change on the ranching industry.

5.4 Appendix IV

NEWS | Climate Change Survey

Climate Change Survey

The BC Cattlemen's Association and Thompson Rivers University, Kamloops BC are partnering to conduct a survey to find out your thoughts on climate change and its impact on cattle ranching in BC.

The partnership is part of an effort to learn current range management practices and whether variations in climate have resulted in adapting these practices.

BCCA members in each region will be randomly selected to receive this survey by mail. Members will be selected based on region to account for differences in management practices, experiences and obstacles based on location.

The ultimate goal of the project is to get the most accurate picture of how climate change may be affecting BC beef cattle operations. To reach this goal, the survey will also be available online for those who do not receive the survey by mail or for producers who are not current BCCA members. To complete the survey online, visit www.surveymonkey.com/s/cattleranchingandclimatechange.

As an added incentive, those who complete the survey will be entered to win one of three prizes. Participants will be eligible to win a credit at their local farm supply store. There is one $100.00 prize and two $50.00 prizes available to be won!

Results from this voluntary survey will be used to help the BCCA and the provincial government develop range management strategies that take into account regional variations and fluctuations in global climate conditions.

Understanding what cattle ranchers are experiencing and observing so management plans can be tailored to specific regional needs and concerns will make these strategies more effective.

Please take a few minutes to share your opinions and experiences. If you have any questions or concerns about this survey I would be happy to speak with you. I can be reached by email (truclimatechangesurvey@gmail.com) or by phone (250-852-6283).
Mercedes Cox
MSc Environmental Science candidate
Thompson Rivers University

5.5 APPENDIX V

5.5.1 RESPONDENT COMMENTS

*Note: comments have been edited for grammar and spelling, but not content.

- *I do not think anyone can change the climate. They can't even predict the weather.*
- *If there actually is global warming it is not affecting us presently. Our problems are weeds, wolves, and fuel taxes and regulations.*
- *You have to adjust to it. What can you do for us?*
- *If it is happening what do you think we can do about it?*
- *I believe increased population in the Okanagan is affecting agriculture more than climate change.*
- *Thank you for showing some interest.*
- *While weather changes it never has been exactly the same or the ice age would not have melted. Who says weather must remain the same for decades? Instead we need to relate to our surroundings and replace what we destroy. Has the reluctance to let forest fires burn aided the beetle populations? Have logging practices been totally beneficial to forest health? Has the ranching industry respected the grasslands and water sources? etc...*
- *This questionnaire did not separate range water needs and private land needs. Water and forage on rangeland is adequate. But water requirements on private hay field are definitely inadequate, although we have water rights dating back to the 1880s. Needs of people who boat on Chimney/Felker Lakes seem more important to government!!!*
- *Global climate change is a hoax!*
- *I believe in climate change. Our weather is no colder or possible hotter than past?? It seems we get our rains for hay and pasture at the wrong times!! In Central BC could it be because of our dead pine??*
- *Cooler, dryer spring/summers have lessened hay crops. But there is no rhyme or reason as to why some fields are more productive than others. Wolves and cougar predation are a huge issue in our area.*
- *We feel the bug kill problem (depravation on trees) is a significant problem concerning water. Climate change?? Logging, bug kill, has opened up opportunities for wolves to invade non-traditional areas (ours and where our cattle range). Climate change—this is of extreme importance to us. If we incur more losses in 2011 we will be in trouble.*
- *Planning for changes in rangeland is critical for keeping ranching stable as possible.*
- *Climate change in the area I live in has not manifested itself in global warming. On the contrary it seems a cooling trend is occurring resulting in longer winters although*

extreme cold is not common lately. Currently we are experiencing record snowpack resulting in added operating costs. I do believe that greenhouse gases must be controlled. So called "global warming" is a term used by those who would benefit from using it, case in point, our provincial government imposes a carbon tax on already high priced fuel. This has not and will not affect greenhouse gas emissions but serves to place an added burden on farmers and ranchers.

- *What I have read makes me believe it has not been proven. "Great Global Warming Swindle" debunks the whole thing. The 1600s had highest CO2 levels ever and was a period of unprecedented prosperity. Our biggest range challenge is noxious weeds.*
- *Drought is the most significant challenge currently facing operation (comment on question 7). How do you know climate change is causing our problems and not climate change that would normally occur?*
- *We are not sure if global climate change is really affecting us adversely of not, in our region things are about the same as usual. We have had cycles of weather patterns before with dry years and wet years in groups of 5 or more years. Last year was good moisture, years before were dry for 3 years.*
- *I believe that any so called climate change is just a normal cycle and is not man made. My operation has been lucky enough to have not suffered any climate related hardships so far.*
- *Let us deduct farming expenses just like all other businesses can!*
- *As the population continues to grow and areas in North America that were desert are now cities which requires an enormous amount of fresh water, I think there is going to be pressure on agriculture in regards to water use. The question may be, will it be raising and growing food going to be a priority or will it be industrial and residential growth. Agriculture is not a priority in BC especially after what the beef industry has gone through since 2003. It is difficult to comment on the effects of global climate change on ranching industry, since the biggest effect has been how difficult it is to ranch in BC since 2003.*
- *We did not notice much about climate change until the pine beetle forced the logging of a massive amount of trees opening the land up to wind, erosion and fast run off. The faster the government can replant the trees the better!*
- *Too many unknowns at this time and I don't see how you can pin point such effects to such a specific region as in this survey.*
- *We are impacted more by altitude, much less frost.*
- *There are other contributing factors that affect the ranching industry. BSE, high costs of overhead, increasing accountability...Global climate change needs to be addressed on a personal level by education because it will eventually affect all of us. We have read conflicting information about climate change—some say our climate is history repeating*

itself. We would be very interested in a website for additional information. Do ranchers need to haul water to their cattle because of global climate change or because of a dry cycle? Was there years of low snowfall, therefore not enough spring runoff to fill up the potholes a hundred years ago? Present day ranchers cannot decrease their herds during drought years because of high costs therefore they need to haul water or develop other water sources or storage.

- *It is the least of my worries. No mention of ecological goods and services.*
- *Global climate change has been occurring for the last 5 000 000 years. You can't get the weather right three days in advance. What makes you think you know what it's going to be like in the next month much less ten years from now? What happened to global warming?*
- *In this area there are thousands of acres that used to be farm land bought by outside corporations to plant back into trees so they have carbon credits so that their factories can keep pouring out pollution in other parts of the world. This carbon credit thing is a joke!*
- *I don't think anyone really knows what is going to happen. It will affect different areas at different times.*
- *It is BS. I believe it is only a weather cycle and it is a scare to create jobs, money and a wealth transfer from rich countries to the poor.*
- *Don't think global climate change on rangeland is any problem. More problems arise from logging practices that have changed (more slash/debris left on clear cuts, impacting grass grown) and off-road recreation increase.*
- *Somewhat warmer winters are easier on the cattle.*
- *Oil and gas have played a major role in destroying grazing land and we should be compensated accordingly. The provincial government profits from this but do not put anything back. I feel that the Peace country bank rolls the rest of the province and it's about time we get something back.*
- *I think global warming will be beneficial to our industry, though at a cost to the rest of the world.*
- *We are causing pollution but we don't cause weather to change but it is a way to make money for the powers that be. 50 years ago the next ice age was coming, last year global warming, now it is climate change, do you really know? We are going global trade, global government so there is lots of global axes to grind and the grind stone is working overtime. We, the cattle producers of BC or Canada, are so busy trying to make a living that we really don't see what is going on in the world and if we did probably there is not much that we as producers could do. Create the problem, and then offer the solution. We are waiting for the solution. The problem has already been created.*

- *Summer access to water and runoff for crops and winter there are low water reserves. Costs to bring in both in money and energy.*
- *Being a farmer, I am used to all kinds of weather. Nothing we have seen in the last 30 years makes me see a significant trend.*
- *This would be a benefit if predictions were accurate. Experts predicted warmer and wetter for this region but it has been cooler and drier. Climate has been changing for millions of years. If climate change experts are correct things should be better for ranching. Climate changes through cycles. 1920s, 1940s, 1960s and 2000 cooler. 1930s, 1950s, 1970s, 1990s warmer. In the early 1970s most climate change experts predicted we were on the beginning of another ice age. In 1990s most of the same experts predicted global warming. Now the predictions are for extreme weather. What can be believed?*
- *Believe most current events are the result of natural cycles, present day lakes used to be hay meadows etc.*
- *Moisture in the form of snow and rain is our biggest concern. Always has been that way.*
- *Global warming started when the ice age stopped.*
- *Greatest impact is on our hay crop volumes and quality due to dry farming and lack of irrigation options. Next greatest is the huge impact of forest licence level of activity on our range licence area*
- *It seems that we either have drought conditions or too much moisture since the climate change.*
- *I do not believe in climate change it is a cycle that the globe is going through and someone put a name on it—look back in history*
- *It appears that every problem in the world today is blamed on climate change. I have yet to see a government program for agriculture that helped and improved the economic situation for farmers in BC.*
- *I believe that any policy change should come from people involved in the industry (such as BCCA) and not the government. I perceive the government to have a biased and limited knowledge of this problem.*
- *I am not at all sure human activity causes climate change or that climate change is bad for me. After one year of drought we have had a wonderful year for moisture and growth. I have no range but do notice range holders abuse range in favour of private holdings. Reservoir/dam safety is applied inconsistently.*
- *The climate will change always. They can't tell if it's warming or cooling. Quit chasing fads and just do your job of adapting to what's played.*
- *There are too many natural events occurring to blame entire notion of global warming on human activity i.e.: volcanic activity, earthquakes, effects of solar activity—flares and sunspots, historical events—dirty 30s, droughts of mid 1800s. Much of current forest*

(pine beetle) is less than 300 years old except coastal interior wet belt. What happened prior? There is a notion from urban populations that farming is a cause of global warming. Need to pursue education that farmers/ranchers are stewards of environment. Farming activities have to maintain land and water quality to be sustainable.

- *Suck it up. Look after yourself with best information and management practices. Don't look to someone for a bailout or rescue. If climate won't support current practices, change!*
- *Changing weather patterns always affect farming and ranching but we just have to adapt to the situations and be more diligent in our efforts to protect our water sources and grazing lands. Fuel prices and the cost of producing hay and crops to feed our cattle are far more challenging on a day to day basis.*
- *Not sure if there are any effects of global climate change on the ranching industry in my area except for drought, which also happened about 60 years ago.*
- *Very concerned about loss of ecosystem restoration. Grasslands are suffering immensely from forest ingrowth (15 percent per year). Grass is every bit as good for carbon sequestration as trees if the grasslands (ranges) are properly managed. Overpopulation of wildlife in the East Kootenays make proper management of range very difficult (they don't know about rest/rotation). "Science" indicates the Earth has seen these climate changes in the past but there seems little doubt that mankind's dependence on fossil fuels is exasperating and perhaps speeding up the arrival of inevitable climate change or "fluctuation"??*
- *If there is global climate change the only effect on our ranching operation is the winters seem to be a bit less cold, especially over the last 10 years.*
- *Our life and livelihood is directly connected to the physical earth: the soil, the water, the air, the rain. If anything is out of balance, so are we and our animals. There are many things we can compensate for, and we've all gotten very creative over time but it's frustrating to watch other humans purposely being destructive and then we have to deal with the consequences. Climate is all about change; it's an integral part of nature. But government and industry behaviour and policies have a huge impact on our responses to that change. Ranchers are REAL environmentalists; we live close to the rhythm of earth every single day. It is always first about maintaining good health and balance for us, not the money so why don't others listen more to our voice?*
- *I feel that climate change is history repeating itself. We were covered by ice at one time—no cows then.*
- *Not convinced about global climate change being the disaster that many people are pushing. Cyclic change that lasts for ten to twenty five years has been occurring forever. Have a look at the urban development where the historic weather readings are taken thus increasing the recorded temperatures.*

- *I feel global climate change is mostly natural and there is little man can do to change it.*
- *Lack of normal snow fall for the last 8 to 10 years has caused water streams and water holes to dry up by mid-summer. Fuel costs have made it uneconomical for moving cattle. Lack of normal rainfall has a terrific effect on forest and grass growth.*
- *Questions are too vague to determine any value from the answers. I would not want to invest more ranch dollars into Crown range when all other users get free access with no penalty for damage.*
- *Our industry is not responsible for a lot of "emissions"! We care for the environment much better than any other industry! I would like to see "pollution" addressed and also (especially) have regulations regarding trespassing on farms and ranches and knowledge to be given to urbanites about the POSITIVE side of ranching. We do all kinds of environmental good through regulations and environmental farm plans that is not credited to us! We should be reimbursed for our efforts to do things "right"! The carbon tax should be refunded to farmers because we are producing food and we can't stay in business much longer doing the "right thing" with the carbon tax!*
- *Global climate change is not due to causes by humans.*
- *Fires have destroyed range land and forests which changes the range management practices. Cutting of the beetle trees have opened up the country to wind and severe extremes in fast weather changes and patterns. Building dams and large lakes i.e.: "Site C" has a horrible impact on climate change. Williston Lake and Kinbasket Lake changed the weather patterns in the Prince George area over my lifetime.*
- *20 year variance from norms does not necessarily equate with climate change. Also I do not see how a 1/2 degree shift in temperatures annually can equate to every winter since 1993 as being way above normal temperature to kill pine beetle.*
- *The lack of moisture in our area for the last number of years and the lack of government assistance to help i.e.: grants to fence hay yards. Crop insurance is diminishing to nil.*
- *Have sold all our cows this year as it is no longer a viable operation due to low prices since the mad cow outbreak. Prices are just getting back to where they were at the outbreak and all other prices such as fuel and hydro have almost doubled and will put the property up for sale.*
- *We always need to respect mother earth and the environment around us. Humans may have a small impact on climate change. The Arctic was a tropical zone thousands of years ago and no man is going to stop the change in climate on earth when its time comes again.*
- *Global climate has also impacted wildlife migration and/or territories. Wolf predation is an extremely increasing issue in our area. Our losses are significant and are pushing us into the possibility of losing our Crown tenure due to loss of profitability.*

- *The entire questionnaire appears to be predicated on global warming being a fact. I seriously question this statement and still believe that we are just into yet another dry or drought cycle in Western Canada.*
- *The so called climate change is just a cycle that has not been seen or recorded before. To let government to be involved is going to allow another type of beating stick to use on food producers. It is trumped up hype to allow big business to gain another way of making money for themselves. As for carbon credits, this is a joke—big corporations are allowed to buy credit from someone else and not correct their own pollution.*
- *In the past, our range area has had more adequate rain and snow. In the last ten to fifteen years we have had on average less snowfall in the winters. The result is ponds going dry and less water in springs and creeks. We have gone from abundant to barely adequate water supply. It if continues to keep getting drier, it will have a major impact on my operation.*
- *Mountain pine beetle has been one of my main range concerns along with low cattle prices to do range maintenance. I am not convinced the MPB epidemic is all due to climate change.*
- *Global warming and the ice age are all natural occurrences. Alberta had dinosaurs at one time then the ice age came and they all froze. Now, we're in a warming trend again, saying it is man caused is bull shit. Also it is said that cattle produce methane gas and cause global warming. What about the millions of bison that roamed the prairies for hundreds of years? The government is using global warming by man as an excuse to suck more money out of everyone.*
- *I like the Kootenay area. I don't wish to blame ranching or climate change for whatever.*
- *Climate change, if you look at history, has changed more dramatically before humans than it has since.*
- *I feel it is too late to change global warming. We have to learn to adapt to the changes. Info on strategies would help.*
- *The first fifteen years I ranched here putting up the hay crop was never a problem. Since then I have been totally rained out one year, followed by a semi drought the next year, etc., etc., Last year was a 3/4 loss of hay, we had frost every night for all of June - affecting the hay crop. Although we had two early rains they were too early to do any good, the June frosts were followed by a complete drought resulting in only 1/4 hay crop. Meanwhile the smoke from Pelican Lake wildfire is terrible. Looking back, 2010 was the worst year I have ever experienced in my whole life. All that was followed by four feet of snow.*
- *Having lived in the area for nearly 80 years I've lived through wet years, dry years, cold years and warm years so there hasn't been any great changes.*

- *The amount of water that the oil and gas uses is a great concern to the agricultural industry.*
- *Pine beetle has impacted weather more than climate change.*
- *Would like clarification of global warming—do you mean as it relates to man-made effects, or to ongoing earth patterns such as natural causes i.e.: some winters are more extreme than others?*
- *I feel ranchers have a much better perspective and ideas re: land use than government officials. Family has ranched in area for 24 years but at a different location. I feel this whole global climate change thing is somewhat blown out of proportion. Yes we are doing many harmful things to the environment but I think part of this warming is also part of nature's natural cycles. We have to learn to change and adapt as ranchers have been doing for years.*
- *Carbon tax on fuel has done nothing but increase operating costs.*
- *I think it is greatly overrated and some people or organizations are getting well paid to do it.*
- *The battle for our water and forage must continue. We must not let the recreation users take us over. BC will become a total recreation province with no grass and no beef—no hamburgers.*
- *The global climate change has been in a constant state of change since the beginning of the earth! Man is an insignificant player with an inflated sense of his control of the weather and his planet.*
- *I would rather see them work on improving markets and reducing input costs. I intend to manage my Crown range anyway. We have been ranching in this location since 1920 and raising cattle for approx. 80 years. Throughout this time there have been dry spells, wet spells, grasshopper plagues and severe weather events. There have been years when the cows grazed out until after Christmas and years where it snowed at the end of October and we had to start feeding them. 2008 and 2009 were two of those early feeding years. Spring did not come any earlier either. This area has always had variable weather. No two years are the same. I cannot say that the current dry spell is unusual.*
- *This government has abandoned range. I have a degree in agriculture and spent my career in range management; I don't need a monitoring program. My entire Crown range lease burned this year. All of my fences were lost, cannot use! In many places productivity of Crown range has significantly decreased. Ranges no longer support the cows as they once did. Cattle numbers need to be permanently reduced in some areas. There is very little water left on the Chilcotin plateau.*
- *I don't believe global warming has affected climate change. In the winter of 1930-31 there was no snow; it was a reasonably mild winter. The winter of 1942-43 there was hardly any snow and a very early spring. There has been winter when we haven't had*

snow until the end of December and been winters when we've had snow in October. Through the years there have been wet years and dry years. I don't think things have changed.

- *In my area I do notice we have been in a drought situation the past 15 years. The seasons are approx. one month earlier. We don't receive the warm spring rains in March, summer is not as hot, fall is the same and winter is not as cold for long periods of time and receives less snow. But mainly the problem is, if we don't receive inflation costs for our product I guess all the questions won't matter. We won't be in the cattle business anymore. That's the bottom line!*
- *The world is always changing you can learn to adjust and carry on.*
- *The only real change in this area is the winters are warmer. Summers wet or dry. On average things seem to work out the same.*
- *While I agree the climate is changing this could be a "normal" weather pattern. We don't have enough years of climate info - say every 500 years. On the big scale I am sure the increase is causing more change to the weather then all our human activities. In the Southern Interior we saw a change to climate here after Mt. St. Helens erupted.*
- *I believe climate change is an ongoing process of nature. It all depends on where and when we are affected. These cycles can last for a few years or over thousands of years. It's nature.*
- *Population growth and use of land and water is a bigger problem than global warming!*
- *Horse flies increasing. Too much sun on the plants.*
- *We don't use Crown land so can't speak for those who do. Rather than incentives for global warming—guaranteed minimum price for cattle as opposed to incentives are what we need. Make environmental farm plans, verified beef programs, age verification etc. worth something. Global warming is not going to make or break my operation at this time.*
- *Please note: we have an environmental farm plan, attend range school—these are excellent programs and should be encouraged. Concern that severe weather events (disasters) will increase in frequency and severity which will bring huge economic impacts to us all, perhaps to the point where businesses that rely on the land/weather will not be able to succeed.*
- *Having been forced into semi-retirement by the BSE crisis, I don't think it is going to matter to the industry because if the financial impacts of events over which you have no control cannot be stopped there will be no industry to worry about.*
- *Climate has always and continues to be dynamic. Fossil fuels are already becoming limited and the globe will heal. We are along for the ride. Hopefully proposed solutions will be applied globally as we can't afford more of what we see in fuel carbon tax, which puts us at a global disadvantage. If this province is going to sustain its ranchers it needs*

to bring back our quality of life and quiet enjoyment and provide us a playing field where we are at peace doing what we do on the land base.

- *Cattle numbers down due to BSE. I do not believe in global warming as some would have us believe. I do not believe in carbon offsets—is designed to be a money transfer and if you believe carbon should not be produced, it is still going to be produced. It is quite obvious we are in a dry trend, but this kind of thing has happened throughout history. If it continues we will need some other water development on Crown range. The thing that is costing us the most on Crown range is the filling in of clear cuts with trees, making it harder and more time consuming to find cattle when cleaning out an area of cattle.*
- *Government policy on addressing global climate change will have the greatest impact on the ranching industry in a negative way. I.e.: carbon offsets, cap and trade, all will increase costs with no net benefit or change to global climate change. Global climate change is a natural evolution that has gone on since the beginning of time.*
- *With an average precipitation of 18", there is no change in forage production. Climate change is in progress since 1941 here in our area since 1958 - warmer winters, less snow - strong fluctuations in precipitations. Effects of climate change are not a big concern for our operation. Big concerns are: finance, irrigation systems (water we have), fuel and fertilizer prices, beef prices and less government regulations.*
- *There is a global climate change, no doubt, how much is really man-made? Petty prices for cattle and some appreciated (financial help?) for ranchers would help more than anything else. If a government wants cheap food for all, it must support the producer. The producer is the key for quality of food and environment and life.*
- *We do not use range land—not eligible—but we can see a definite change. Also poor stewardship. Water is drying up faster; grass is not growing to feed animals.*
- *Beaver Creek going dry and well is going dry.*
- *This is an interesting topic and a useful survey. Global climate change is a real issue and it will impact agriculture, particularly concerning water quality and quantity. In the East Kootenay region, particularly in the Upper Columbia (Canal Flats to Spillimacheen) mostly the crisis will be driven by recreational properties and municipalities.*
- *Few seem to realize and accept that the immediate future and condition of our rangelands are going to be much different and therefore more challenging to manage than what we have been and are just now experiencing. Livestock access to water will and must change for the overall benefits of both ecosystem and human health. Hopefully the new Water Act for BC will ensure there is much better management of BC's water resources in the future than there presently is.*
- *Without access to water we won't be able to produce food. Please make sure people understand a cow has to drink to become a steak.*

- *Climate change is not the most significant threat to the cattle industry in BC. As the president of our local association, I have heard many of my own concerns repeated: Prices, conflict between urban and rural people, cost of farming and BC's terrible agriculture policies are far more to blame than climate change. The rewriting of the Water Act is a prime example. Agricultural water use is lumped in with industry while First Nations are not lumped in with public water use. While First Nations are part of the public, agriculture can't be lumped in with mining, logging or manufacturing or hydro. It is food production for God's sake.*

5.6 Appendix VI

5.6.1 Introduction

While climate change models indicate general range contraction of sagebrush in the southern part of its range; this shrub is predicted to expand its northern range—including BC (Parmesan & Yohe 2003; Root et al. 2003; Schafer et al. 2001). Encroachment of woody shrubs can change surface albedo, evapotranspiration, runoff and fluxes of trace gases to the atmosphere, altering the hydrology of grasslands (Polley 1996). It has also been suggested that drought conditions reduce forage abundance, facilitating the establishment of sagebrush (Harniss & Murray 1973). In areas where increased drought conditions are expected, the removal of sagebrush has even greater implications as long-term studies suggest that sagebrush control can increase water yield and the water recharge capacity of the soil (Sturges 1993). Monitoring the regrowth of sage for 30 years after a burn has strongly indicated there is the need for sage management in order to maintain maximum forage qualities (Harniss & Murray 1973). This sentiment is echoed by West et al. (1984) who studied the reestablishment of forage grasses for 13 years after building an exclosure. They state that direct manipulations of woody shrubs are mandatory if rapid return to grass dominance is desired in such environments.

Increased control of sagebrush may be required under changing climate conditions because both wildlife and livestock are dependent on sufficient forage production. Typically, the expansion of sagebrush comes at the loss of other plant species—especially forage grasses (Fowler 1986; Van Auken 2000). When sagebrush expands its range in BC, direct management of grasslands may be required to meet the forage and grazing needs of both cattle and wildlife. An adaptive management process will be required (Westoby et al. 1989) to adjust to the new realities global climate change will produce. As Figure 1 indicates, grazing often contributes to the increased success of woody seedlings by reducing the herbaceous layer. This, in combination with the predicted impact of climate variation, has the potential to significantly impact the amount of forage available for wildlife and livestock (Asner et al. 2004).

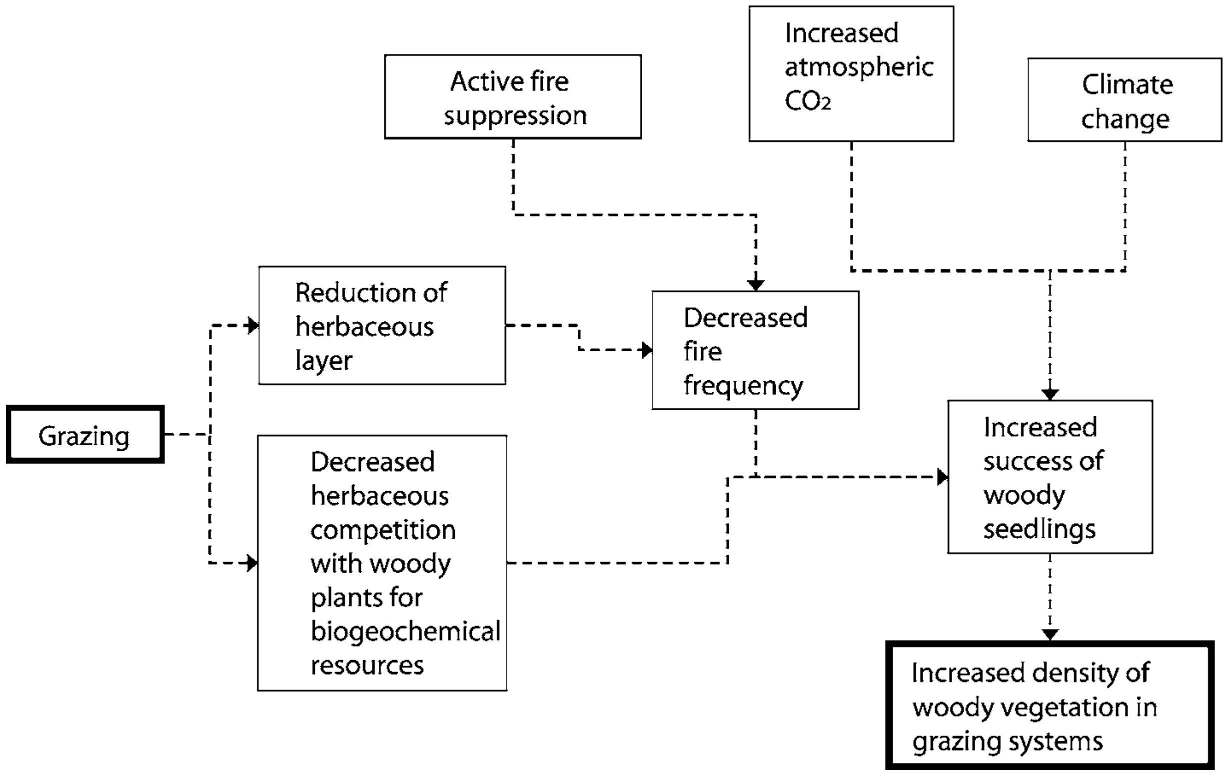

Figure 5.6.1-5-1: Processes contributing to woody encroachment in semi-arid systems. Climate change is expected to lead to an increased success of woody seedlings, such as sagebrush (From Asner et al. 2004).

The general predictions of climate change for the Thompson-Okanagan region is for hotter, drier summers and warmer, wetter winters. Similar patterns have been observed in the Chihuahuan Desert systems of Arizona and New Mexico, an area similar to the low elevation shrub grasslands of the BC Interior where shrub density increased three-fold over thirty years (Brown et al. 1997).

Historical records indicate that sagebrush was present in the grasslands of interior of BC, but were sparsely distributed and that many of the slopes now dominated by sagebrush were once predominately grass. These records accounts also suggest that the removal of grasses through foraging, especially in the lower grassland zones, facilitates the encroachment of shrubs such as sagebrush (Tisdale 1947). The extent to which an increase in shrub cover reduces the total amount of forage grasses is unknown. Laycock (1967) denotes that heavy grazing in the late fall increases the amount of available forage by reducing sage abundance while increasing the abundance of forbs and forage grasses and that heavy spring grazing has the opposite effect and promotes the proliferation of sagebrush.

Warming of the climate is a contributing factor to the encroachment of woody shrub species into grasslands (Van Auken 2000; Perfors et al. 2003; Zavaleta 2006; Asner et al. 2004) and may influence the availability of suitable forage by decreasing the overall amount of grazing land. *Artemisia—Pseudoroegeneria* bunchgrass ecosystem grasslands are essential for many species; however, sagebrush competes with grasses that provide forage to wildlife and livestock. Climate change, succession and disturbances have the potential to change the density of sage. Future management of shrub encroachment is an example of a range management practice that may need to be adopted in response to climate change.

5.6.1.1 Study Objectives

Big sagebrush (*Artemisia tridentata*) was manipulated in a field experiment in an attempt to investigate whether sage abundance affects the amount of forage land available. As vegetative composition on rangeland expected change in response to changes in climate, it is important to understand how vegetative interactions may impact available grazing forage. This project will attempt to answer the following questions:

i. What are the vegetative changes that occur under different levels of sagebrush cover?

ii. How is plant community composition and forage productivity affected by different levels of sagebrush abundance?

iii. How is soil moisture and temperature affected by different levels of sagebrush abundance?

5.6.2 METHODS

The field research was conducted over two years at a mid-elevation in the grasslands of Lac du Bois Provincial Park (Fig. 5.6.2-1). Previous experiments in the area have examined the use of fire and herbicide as mechanisms of sage removal to encourage forage production. Climatic factors such as annual temperature and precipitation were considered and compared to historical values. Changes in seasonal variations were compared to any changes in vegetative cover of *Artemisia tridentata* and will be taken into consideration when attempting to determine if these factors play a role in the pattern of sagebrush growth (Tisdale 1947). Zones identified by Van Ryswyk et al. (1966) will be used as baseline comparison for areas of sage growth.

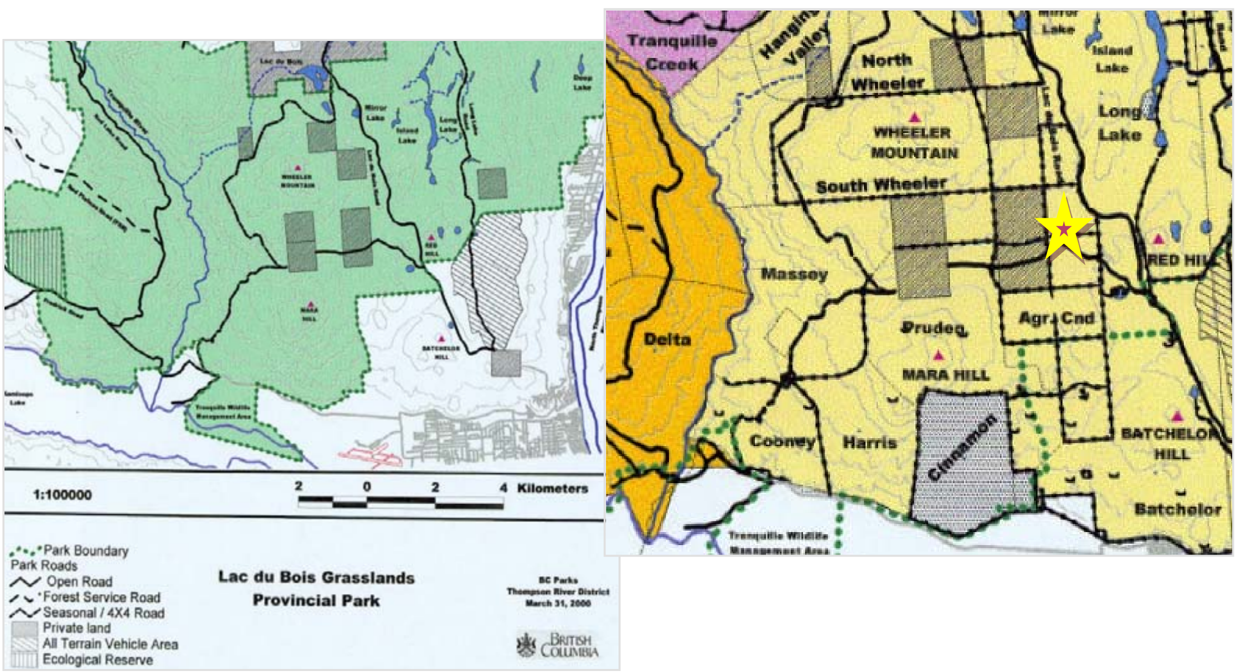

Figure 5.6.2-1: Map of Lac du Bois grasslands Provincial Park showing park location and boundaries (left) and (right) map showing approximate field study location in Agriculture Canada research plot within Lac du Bois grasslands.

The selected study site (Fig. 5.6.2-1 (right) is an existing Agricultural Canada exclosure previously used for sage removal research in the early-mid 1970s. A rotary mower was used first to knock down the big plants then the area was boom sprayed with a herbicide (most likely

2-4-D), leaving behind the strips of sagebrush that were used for this study (Fig. 5.6.2-2). The area was then used for a grazing trial with a small number of cows grazing for 2 days a week for 4 weeks. The trail was testing impact of grazing on April grazing versus May grazing, but no significant results emerged (Rick Tucker, pers. comm).

Figure 5.6.2-2: Photo showing study area and the rows of sagebrush used for the field study experiment.

Sagebrush was removed from plots in different densities and the response of forage grasses, the plant community and soil characteristics were compared to control plots containing sagebrush. All experimental plots (2m x 2m) were located near other grasslands classified as *Artemisia – Pseudoroegeneria* bunchgrass ecosystem. At the site-level scale sagebrush cover ranges from 0 to 100%. Sagebrush was removed from plots in the spring of 2010 in a manner that created a gradient of sagebrush cover. All plots were selected to have an initial sage cover of as close to 100% as possible. Removal was done in a manner that reduced cover consistently over the plot, maintaining the distribution of sagebrush size classes, and minimizing disturbance to vegetation and soil surface. A treatment refers to the removal of 0 (control), 25, 50, 75 or 100 percent sagebrush. The gradient represents a range of sagebrush cover as the level of shrub cover that will begin to influence forage grass production is unknown. Higher densities of sage are necessary represents the potential amount of sagebrush cover under future scenarios.

Table 5.6.2-1: Sagebrush removal guidelines

Percent Removal	Grids removed (out of 16)
0	No Grids
25	1,3,7,16
50	4, 5,7,9,11,12,14,16
75	2,4, 5, 6,7,8,11,12,13,14,15,16
100	All Grids

The experiment consisted of six replications of each removal level, including a control for a total of 30 plots. The perimeter of each plot was trenched to a depth of approximately 10 inches. The sage was then removed randomly from grids within the plot (Table 5.6.2-1) and the same randomly selected grid squares was used for all replications (Fig. 5.6.2-3). Prior to removal, existing sage and vegetative cover was noted as either present or absent within each grid square. Presence/absence was noted again in the spring and fall 2011 prior to the final removal of biomass.

The harvested material from each shrub was sorted into leaves and stems and dried at 65°C for 48 hours and weighed. In August of 2010 and 2011, the inner $1m^2$ plant community was measured after the growing season using the Daubenmire® method (Daubenmire 1966). The subplots were then harvested at ground level above-ground plant productivity in November 2011. Soil moisture and temperature data was collected over the course of the study using Onset Smart Temp Sensors and Soil Moisture Smart Sensors (S-SMB-M005 using a ECH20® Dielectric Aquameter probe, Decagon Devices, Inc) connected to a HOBO® Micro Station data logger, Onset Computer Corporation) in one of the six replications and manually in all plots at the beginning and the end of the growing season using a hand-held thermometer and soil moisture probe. Calculations and information regarding the calibration for the 10 cm long probes can be found in Appendix VI.

Figure 5.6.2-3: Experimental control plot containing 100% sagebrush prior to fall 2011 harvesting.

5.6.3 RESULTS

As stated, all plots had as close to 100% sagebrush cover as possible to start (Table 5.6.3-1). The sagebrush in the 0% cover treatment was removed at the beginning of the first year of the study while the remaining values include growth from the summers of 2012 and 2011.

Table 5.6.3-1: Average amount (Kg) of total sagebrush in each type of treatment plot.

percent cover	2010 average sage biomass	2011 average sage biomass	total average
25%	2252.63	2974.61	5227.24
50%	1374.92	3000.50	4375.42
75%	1293.25	3836.31	5129.56
0%	4175.85	n/a	4175.85
100%	n/a	4390.00	4390.00

Figures 5.6.3-1, 5.6.3-2, 5.6.3-3 and 5.6.3-4 display soil moisture and temperature information collected from July-October in 2010 and March-November in 2011. 2010 figures do not include data from soil moisture and temperature probes in the 0% cover plot due to equipment malfunction. 2011 soil moisture data for 75% cover plot and temperature data for 0% cover plot missing due to rodents damage to the sensor wires. Data is shown temporally at four time intervals: 00:00, 08:00, 10:00 and 15:00.

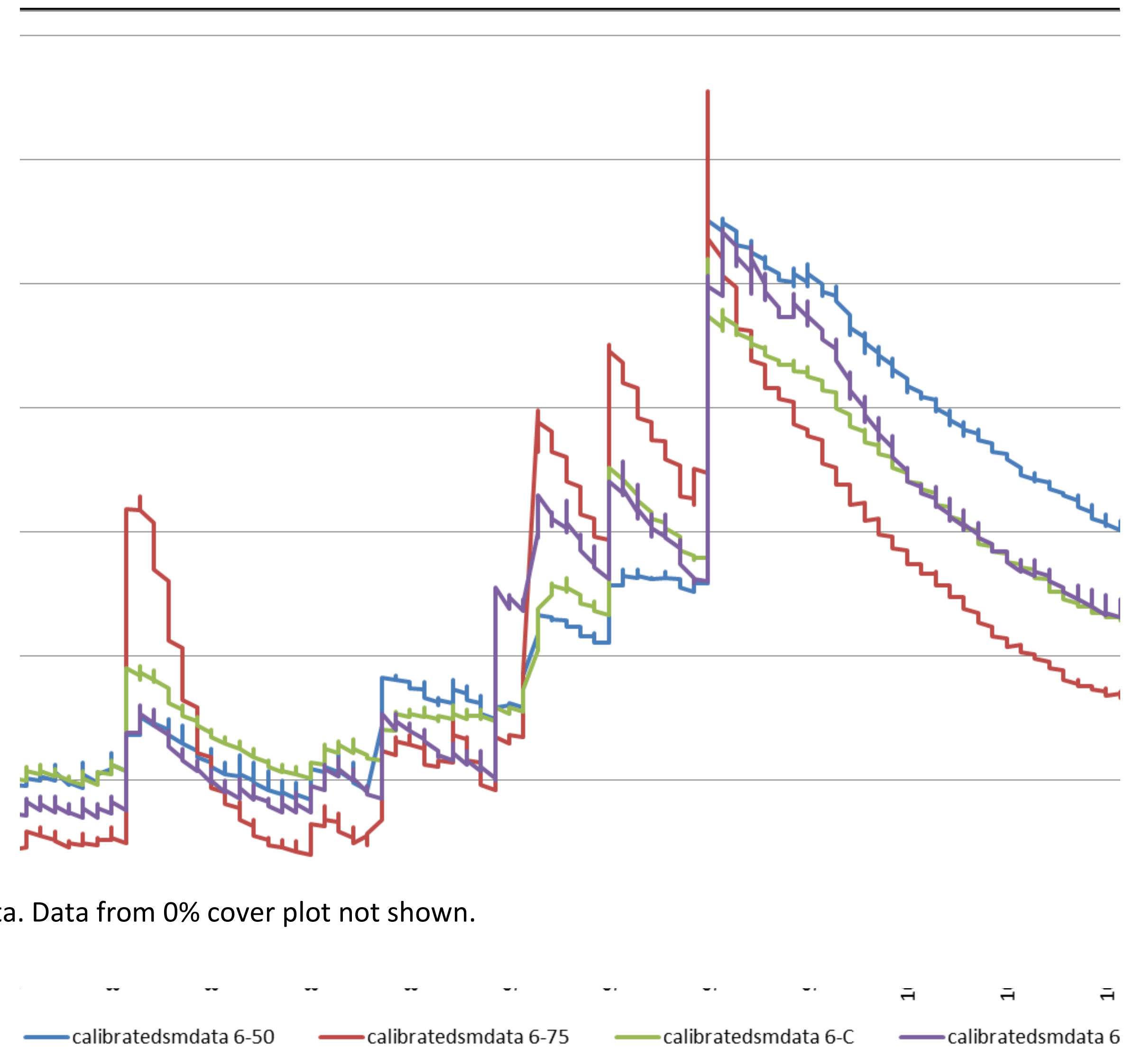

Figure 5.6.3-1: 2010 soil moisture data. Data from 0% cover plot not shown.

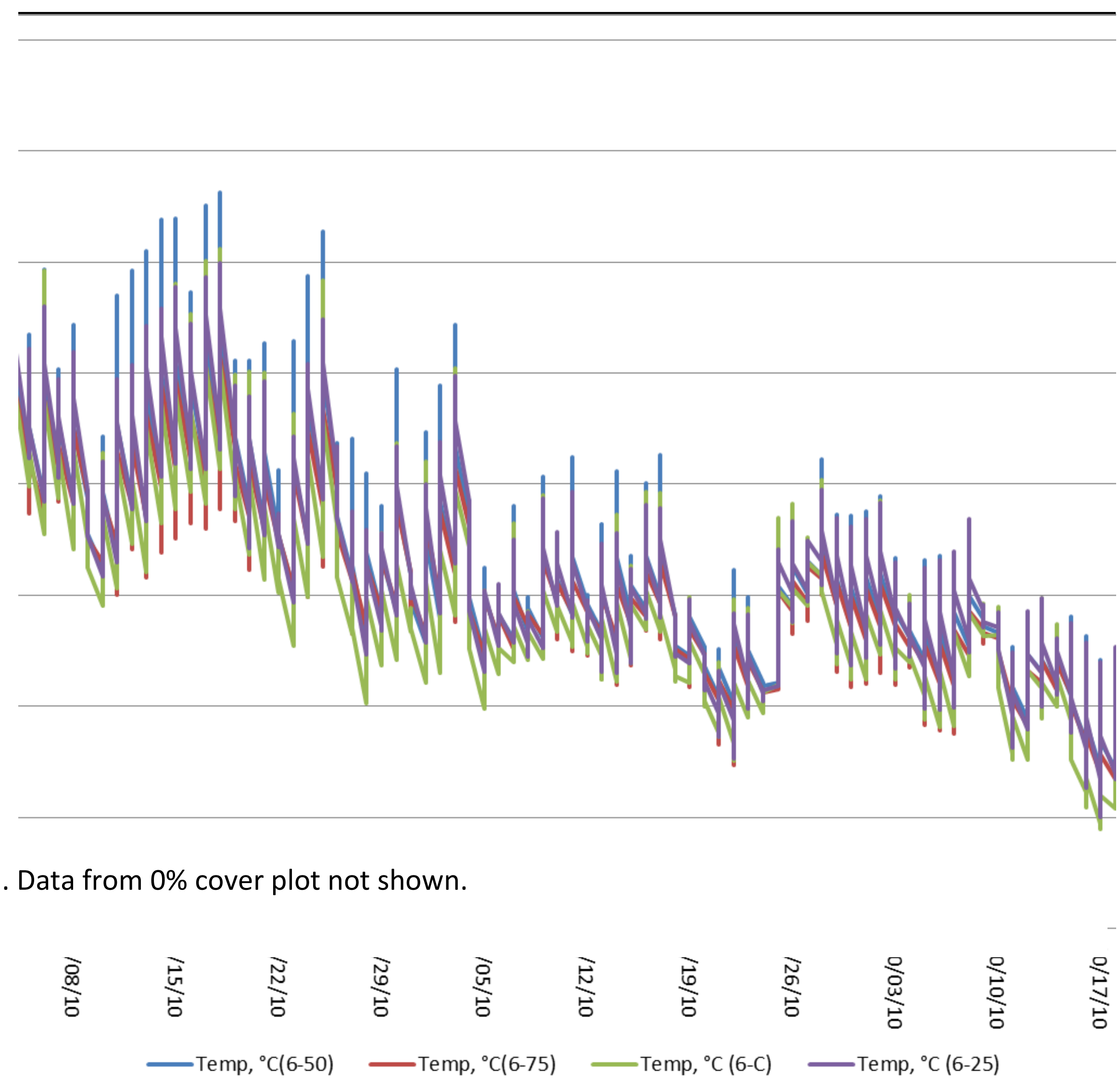

Figure 5.6.3-2: 2010 Soil temperature data. Data from 0% cover plot not shown.

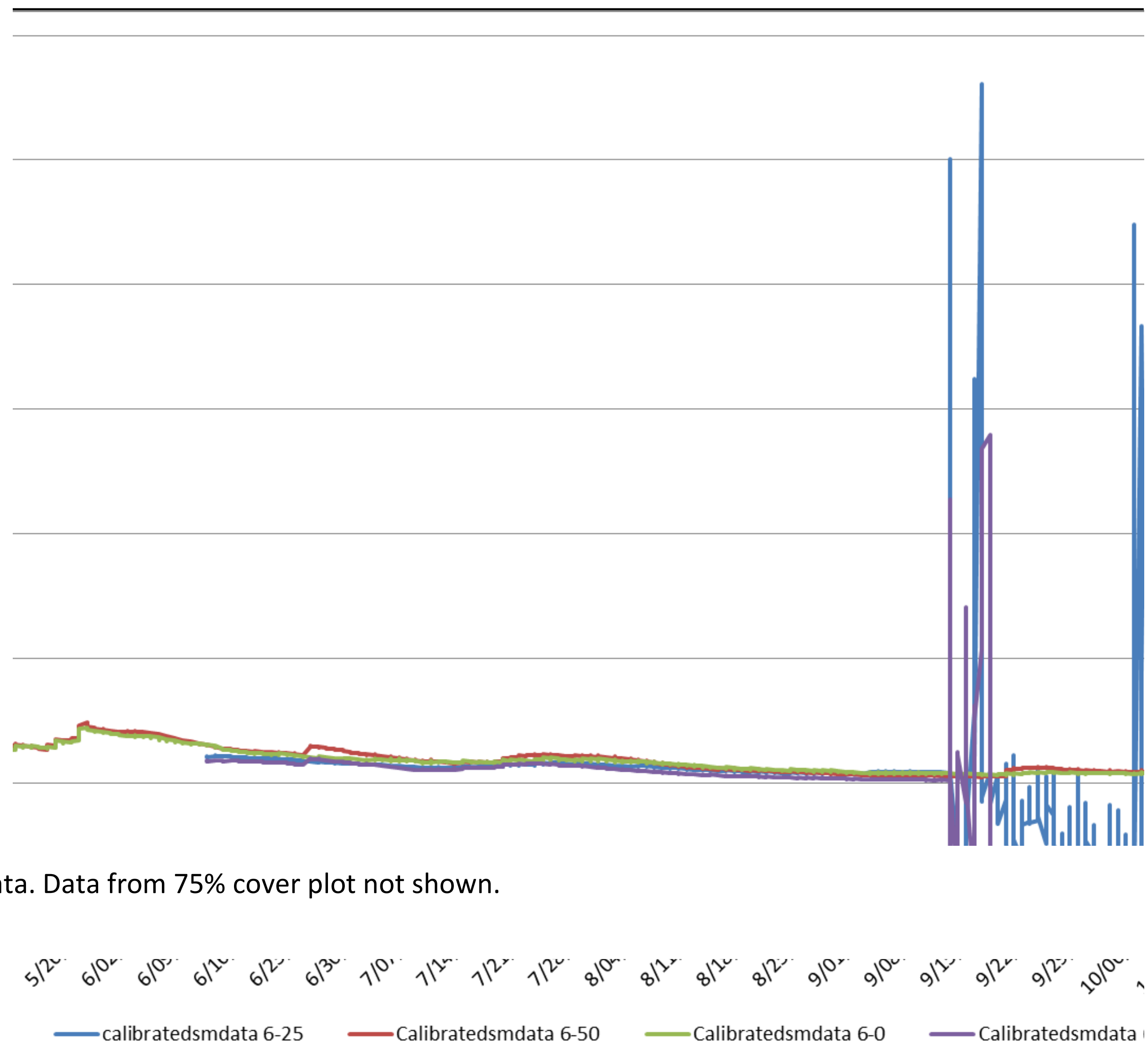

Figure 5.6.3-3: 2011 soil moisture data. Data from 75% cover plot not shown.

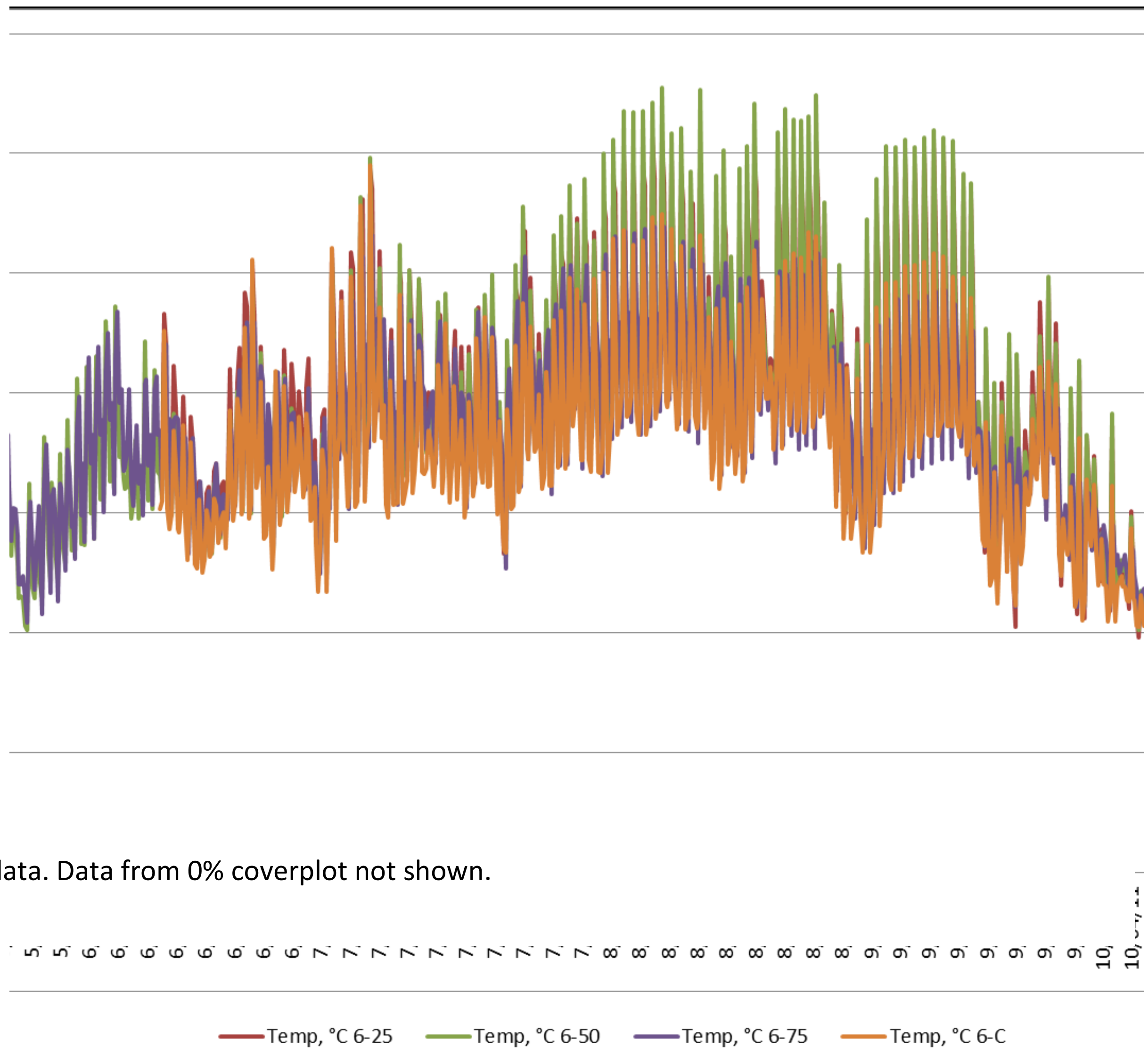

Figure 5.6.3-4: 2011 soiltemperature data. Data from 0% coverplot not shown.

Analysis of variance and linear regression analysis was used to determine if sagebrush density attributed to the variance in the amount of available forage (live biomass) and the amount of total biomass (available forage + litter). Total sagebrush biomass, woody biomass and sagebrush leaf biomass were considered. Results indicate that sagebrush density is a significant indicator of total biomass (Table 5.6.3-2). R squared value (.245) indicates that total sage biomass accounts for 25% of the variance in the total plot biomass (live + litter) (Fig. 5.6.3-5). Woody sage biomass accounts for less than 1% (Fig. 5.6.3-6). ANOVA results for total sage biomass (Fig. 5.6.3-9) and total sagebrush leaf biomass (Fig. 5.6.3-8) and total woody biomass vs. live litter (available forage), and total sagebrush biomass vs. total ground litter (Fig. 5.6.3-7) were not significant.

Table 5.6.3-2: One-way ANOVA analysis of 2011 sagebrush biomass vs. total dead plant litter and total 2011 leaf biomass vs. total live litter (available forage).

ANOVA summary	**Total 2011 sage biomass vs. total biomass (live + litter)**		**Total 2011 woody sage biomass vs. total live litter (available forage)**		**Total 2011 sage biomass vs. total ground litter (excluding live)**		**Total 2011 sage leaf biomass vs. total live litter (available forage)**		**Total 2011 sage biomass vs. total live litter (available forage)**	
	F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
	9.081	.005*	.253	.619	2.762	.111	.067	.798	.237	.630

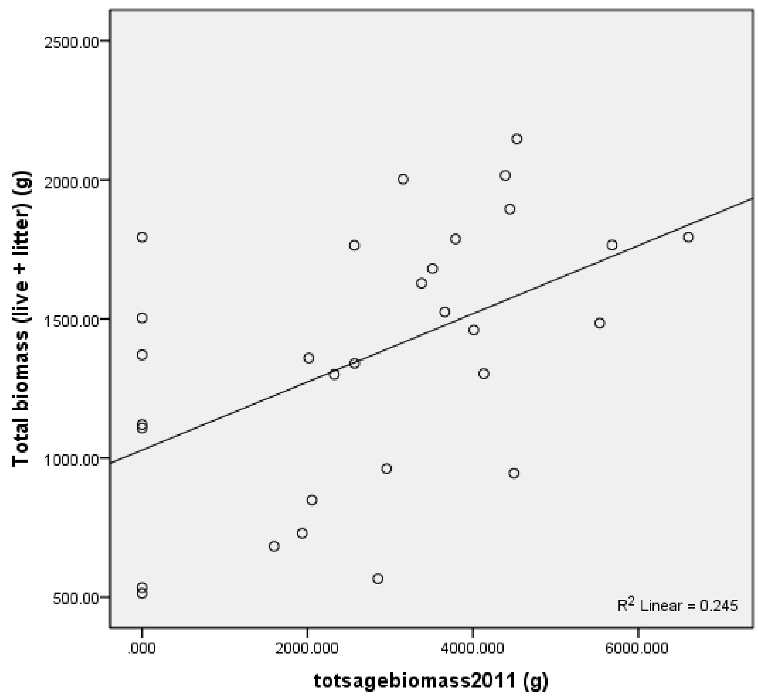

Figure 5.6.3-5: Regression plot showing R^2values and linear distribution of the effect of total sagebrush abundance on total biomass of understory herbaceous biomass.

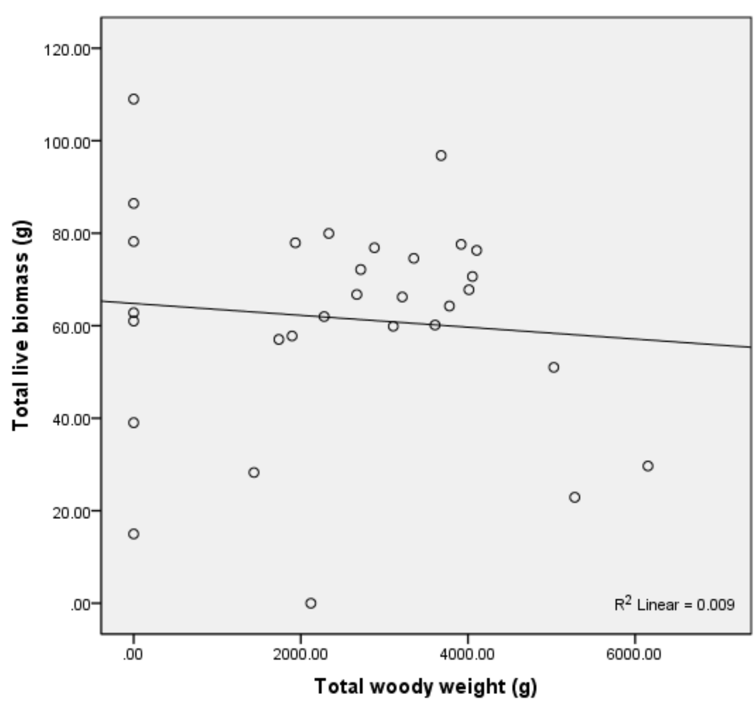

Figure 5.6.3-6: Regression plots showing R^2values and linear distribution of total woody biomass and total live biomass (available forage) (g).

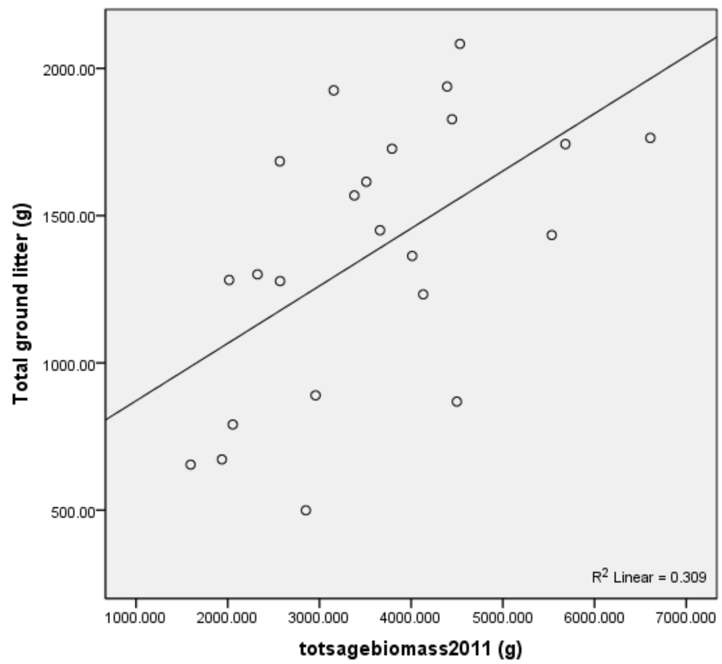

Figure 5.6.3-7: Total 2011 sage biomass accounts for 31% of the variability of the amount of total ground litter (excluding live biomass).

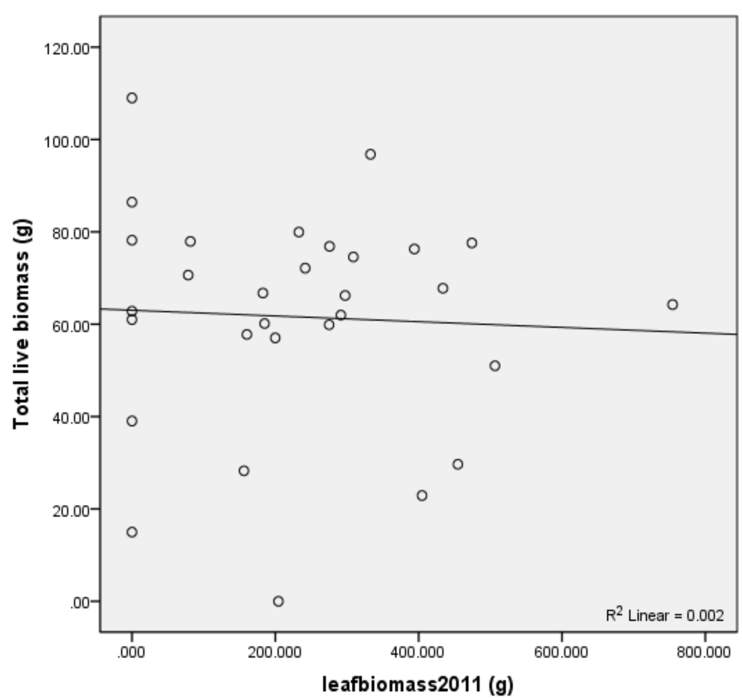

Figure 5.6.3-8: 2011 sagebrush leaf biomass does not account for a significant amount of the variability of total live biomass (available forage).

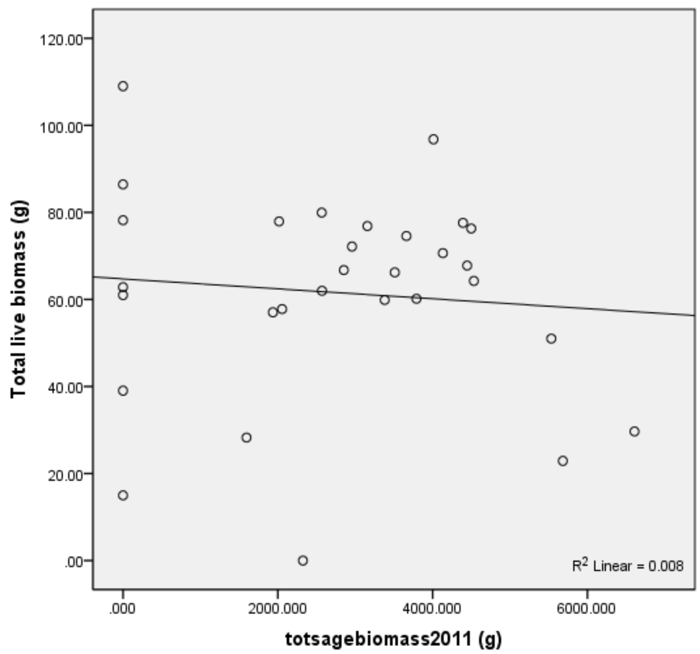

Figure 5.6.3-9: 2011 total sagebrush biomass does not account for a significant amount of the variability of total live biomass (available forage).

An ANOVA of the mean Shannon-Weiner diversity index values for plant species did not indicate a significant difference in species composition between plots or treatments (Tables 5.6.3-4 & 5.6.3-5). Figure 5.6.3-10 displays a summary of all Shannon-Weiner index values by treatment for each plot.

Table 5.6.3-3: Descriptive statistics of Shannon-Weiner index values for each treatment.

treatment	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	6	1.1027	.11765	.04803	.9792	1.2261	.90	1.25
25	6	.7988	.34329	.14015	.4386	1.1591	.38	1.30
50	6	.7692	.47530	.19404	.2704	1.2680	.00	1.35
75	6	.6767	.17449	.07124	.4935	.8598	.43	.95
100	6	.8570	.30470	.12439	.5372	1.1768	.48	1.33
Total	30	.8409	.32273	.05892	.7204	.9614	.00	1.35

Table 5.6.3-4: ANOVA for Shannon-Weiner index values.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.616	4	.154	1.601	.205
Within Groups	2.404	25	.096		
Total	3.020	29			

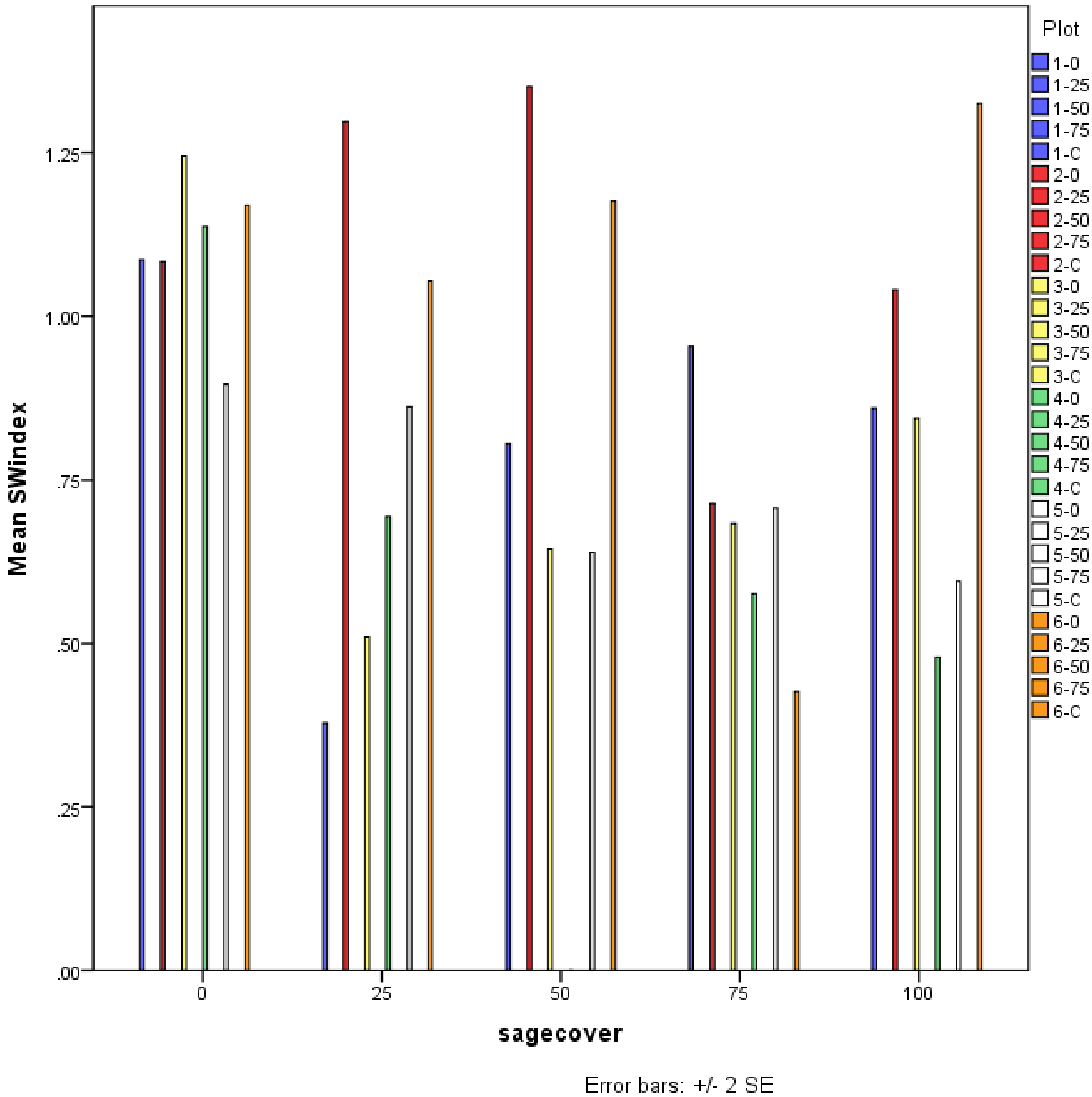

Figure 5.6.3-10: Plot summary of average Shannon-Weiner index values for each treatment.

5.6.4 DISCUSSION

The overall duration of this experiment was relatively short, making it difficult to accurately measure any substantial changes in relative forage abundance in response to the removal of sagebrush. Extending this study over a longer of period of time would allow the system to reach a new equilibrium and state of community composition (Tisdale 1947; Peltzer & Kochy 2001; Berlow et al. 2003; Huber-Sannwald & Pyke 2005). Allen-Diaz & Bartolome (1998) recommend a sampling inventory on a five to ten-year cycle in order to accurately detect transitions in species composition in sagebrush-grass communities. Longer experimental time would also likely allow for a more exacting measurement of any changes in species diversity using the Shannon-Weiner index.

My finding that total sagebrush density influences the amount of total herbaceous understory is significant as this can in turn, influence abiotic factors such as soil temperature and moisture (Berlow et al. 2003). An intermediate density of sagebrush may also allow for the establishment of the seedling of forage grass seedlings as shrub presence offers shade and protection from direct solar exposure (Huber-Sannwald & Pyke 2005). I would suggest that future studies incorporate finer-scale methods of measuring plant growth and productivity such as those employed by Cook & Lewis (1963).

5.6.5 References

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5.7 APPENDIX VI: CALIBRATION OF SOIL MOISTURE PROBES

INTRODUCTION

In the field experiments that manipulated water, temperature and clipping it was necessary to probes to measure the effect of my treatments on soil moisture. However, data from the probes contained a large number of negative values for volumetric water content (VWC) that, by definition, should not be less than zero. An investigation of this problem suggested that this issue was related to the soil type at my experimental site. A calibration procedure was found to correct the problem (Campbell 2002). This appendix details the slight modification to this procedure that was used and provides the correction necessary to properly report the soil moisture data obtained from the experimental site.

METHODS

The same soil moisture probes (10 cm long, Soil Moisture Smart Sensor, S-SMB-M005 using a ECH_20® Dielectric Aquameter probe, Decagon Devices, Inc. connected to a HOBO® Micro Station data logger, Onset Computer Corporation) that were used in the field study were used in this calibration.

Approximately 20 litres of soil was collected from the field site where the experiment was done (Lac du Bois Grassland Provincial park within the bunchgrass grasslands of the interior British Columbia, 6 km north of Kamloops, Canada (UTM E 680737 N 5625980; elevation 731 m a.s.l.). Soil was taken from eight separate soil pits 10 cm deep with the litter layer removed. This was the same depth that the soil probes were installed during the experiment. The soil samples were sifted through a coarse, 5 cm x 2 cm, screen to remove large rocks and break up soil clumps, and then pooled.

The calibration procedure followed Campbell (2002) with a few modifications. The soil was equally divided among 6 containers (40 cm x 27 cm x 17 cm) to fill the container with approximately 10 cm of soil. Water was added to each of the containers to create a range of soil moisture levels, 675 mL, 1150 mL or 1625 mL; two containers received each level of water addition. The water was thoroughly mixed into the soil. Next, two soil moisture probes were placed horizontally 3 cm below the soil surface in each container and the soil was pressed firmly and evenly down. The soil moisture readings were recorded and two soil cores (2 cm radius, 3.5 cm deep) were removed from each container.

The soil cores were placed in jars with lids that had been weighed. The wet soil samples were weighed, then dried for 1 week at 65ºC and then weighed again.

With this information the soil weight, water content, bulk density and VWC can all be determined.

Dry soil weight = dry weight – jar weight (1)

Wet soil weight = wet weight – jar weight (2)

Water weight = wet soil weight – dry soil weight (3)

Bulk density = soil weight / volume of soil core (4)

VWC = water weight/ soil weight x bulk density (5)

To calculate the calibration equation, the actual VWC of the samples determined through the above procedure was plotted against the observed values from the soil moisture probes (using the means of probes in each container). In Excel, a linear trend line was plotted through the data; the equation of this line is the calibration equation.

Results

The calibration procedure shows that the probes underestimate the actual VWC of the soil. Field readings should be adjusted using the equation:

Actual VWC = 1.3885 x Observed VWC + 0.0798

An R^2 value of 0.915 for this regression suggests that a linear calibration is sufficient.

Reference

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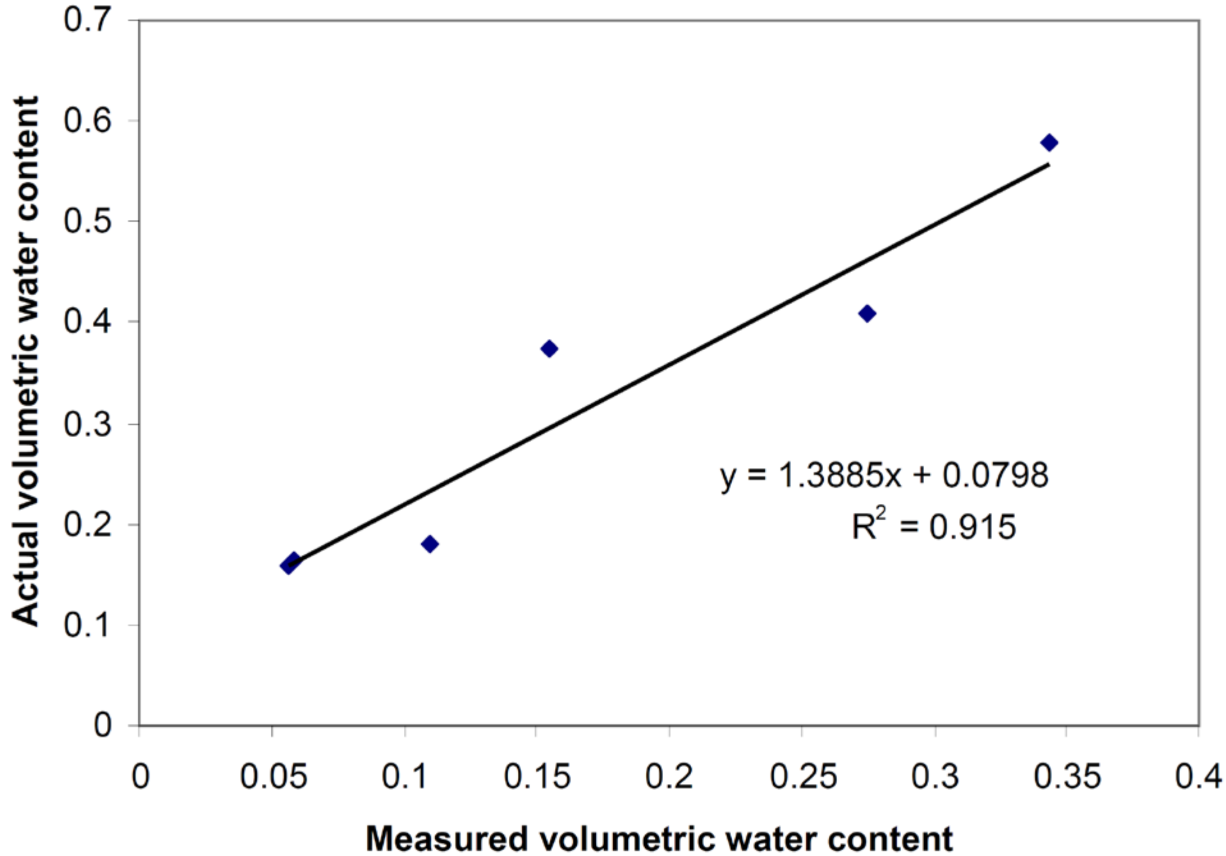

Figure A1.1 Plot from excel of actual volumetric water content plotted against the measured volumetric water content. The equation in the figure is the formula required to adjust field readings.