# Climate Change & BC Range

Cover Photo: Lauchlan Fraser

Published by: TRU Centre for Community and Ecosystem Ecology
Editors: Mercedes Cox, Lauchlan Fraser
Designer: Mercedes Cox

This project was funded by the Future Forest Ecosystems Scientific Council (FFESC), an initiative of the provincial government of BC to support research that would inform adaptation of the forest and range management framework to climate change. The project presented via this website consisted of 10 teams with the overall research being aimed at managing for the ecological and socioeconomic effects of climate change on BC rangelands.

# Project Partners









# Project Overview

Rangelands in British Columbia include grassland, forest, wetland, and alpine range and occupy about 58 million ha, providing forage for grazing and browsing animals. The majority of BC's rangelands are owned by the Crown (approximately 90%), while the rest is privately owned. The province's cattle industry is dependent on sustainable range resources for both forage and hay production. Rangeland also provides wildlife habitat, wood products, tourism and outdoor recreation, as well as education, and wildlife viewing opportunities. Our goal is to inform sustainable management of rangelands in the context of future climate change.

Grasslands are a key subset of BC's rangelands and are a rare ecosystem and provide habitat for many of BC's endangered plants and animals. Rangelands, especially grasslands, are threatened by urban development, agricultural conversion, tree encroachment and infill and inappropriate grazing. Global climate change has the potential to interact with the above disturbances, but the consequences of these interactions for rangelands in BC are not known. The interacting effects of disturbance caused by grazing and climate change, a biological stress on plant communities, will not likely be uniform across rangelands. Variation of response is expected between northern and southern latitudes of the province and by species. The response of a species may depend on its local environment including soil and site conditions.

The effect of climate change on rangelands was investigated using a multi-pronged approach: a review of past and ongoing climate change experiments, field experimentation, socioeconomic analysis of natural goods and services, a survey of the ranching community to determine the ranching perception of climate change, and incorporating the ecological and socioeconomic findings in an integrated range management plan.

The research program provided:

- opportunity for interdisciplinary collaboration and focus on potential effects of climate change on high-value grassland ecosystems
- opportunity to foster productive linkages between universities, government and the ranching industry
- financial support and training for graduate students.

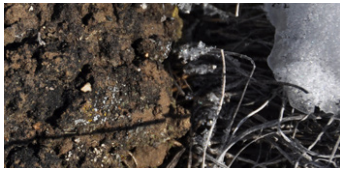
This project was funded by the Future Forest Ecosystems Scientific Council (FFESC), an initiative of the provincial government of BC to support research that would inform adaptation of the forest and range management framework to climate change. The project presented via this booklet consisted of 10 teams with the overall research being aimed at managing for the ecological and socioeconomic effects of climate change on BC rangelands.



Climate change and cattle ranching in BC. A snapshot of how climate change is perceived by the cattle-ranching community and a discussion of future management implications and an assessment of information needs. •



The relationships between plant communities, soil properties, and topography are important for predicting effects of future climate change and the spread of invasive plant species.•





Climatic changes that affect moisture availability, particularly during the winter, could have a significant impact on nitrogen inputs by biological soil crusts.•

## 14–15

How plant communities may change based on shifting rainfall patterns, and the effects this may have on a host of ecological processes is fundamental to informed land management.•

## 16–17

Rattlesnakes in BC are an example of an at-risk species that depend on grassland ecosystems at low to mid elevations. •

## 18–19

Assessing greenhouse gas emissions from cattle grazing on Crown range land in the central interior of BC, will help determine the carbon footprint of BC's cattle ranching industry.•



Ranchers are the stewards of much of British Columbia's grasslands, and maintaining economically viable ranches is essential in maintaining British Columbia's grassland ecosystems•



Developing strategies that will assist range managers in dealing with a set of future conditions that may result from climate change will be key in increasing adaptability. •

Project Overview

# Climate Change & Cattle Ranching in BC

Lauch Fraser, Robert Androkovich & Sadie Cox

Cattle in a grazing pasture in Lac du Bois Provincial Park.
PHOTO: Lauchlan Fraser.

## Our Project

A survey was used to assess the perception of ranchers within the BC cattle industry regarding global climate change. The goal was to answer the following questions:

- Have ranchers noticed changes in climate on rangeland they use? What kind of changes? Are those changes caused by global climate change?
- What is understood about climate change and what it means?
- Have management practices changed due to changes in climate?
- The perceived economic impact of any identified changes.

Agriculture—including ranching—is among the most climate-sensitive sectors in most national economies and climate variability increases the uncertainty associated with agriculture and rural livelihoods. The BC ranching community will be pivotal in successful and effective planning of climate change adaptation strategies. Effective range management and associated policies need to consider changes in annual temperature and precipitation patterns.

## Our Methods

The survey design focused on capturing the current understanding of what climate change is and to what degree management practices have been adapted in response to perceived changes in climate.

In partnership with the BC Cattlemen's Association, a survey was mailed to 581 cattle ranchers across the province. The province was separated into six regions and half of the BCCA members within each area were randomly selected to receive the survey.

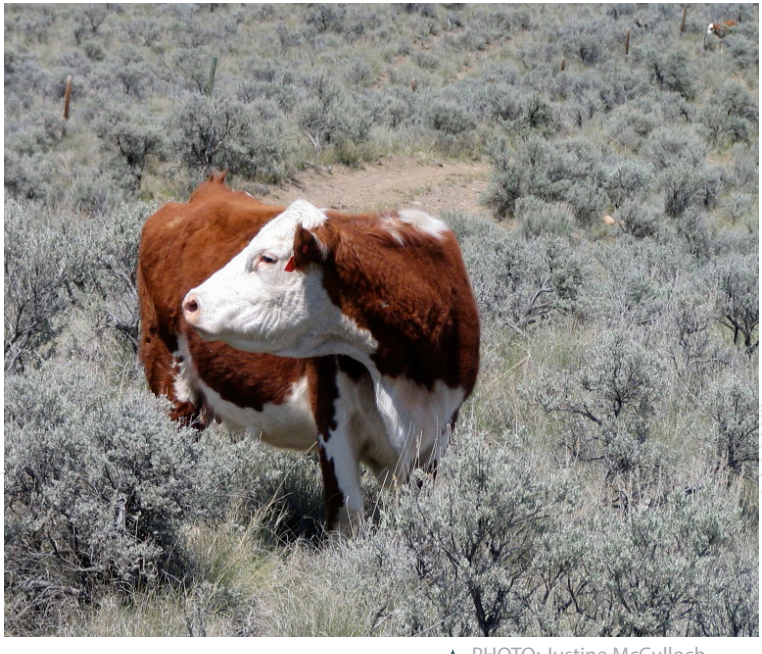


PHOTO: Justine McCulloch

## Project Outcomes

64% of 227 respondants either "somewhat" or "strongly" agreed with the statement: Human activities are increasing the rate at which global climate changes occur.

No economic cost was associated with management changes directly attributed to changes in climate by over sixty percent of respondants. The cost of additional fencing due to pine beetle kill and related logging activites was the most commonly identifed economic burden.

## Future Directions

Information gathered from the survey will provide a framework for developing educational materials providing information to the cattle ranching community about climate change. These materials will be delivered in the format identified by survey respondents as most preferable.

"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 it's history repeating itself."

— Survey Respondant

Project Overview

# Grassland Plant Communities Defined by Abiotic Relationships

Gary Bradfield, Maja Krzic & Robbie Lee


Dr. Gary Bradfield, MSc student Robert Lee, and Dr. Maja Krzic (all of the University of British Columbia, Vancouver). PHOTO: Dr. R. Newman

BC grasslands are an asset to the province's biodiversity, economy, natural beauty, and recreation. For decades, these areas have been largely modified and reduced. They are now threatened by climate change and exotic plant invasions. The ability of land managers to adapt to the effects of climate change and plant invasion depends on having the best possible understanding of these systems.

Group discussion during study site selection. PHOTO: Dr. M. Krzic

## Our Methods

We collected data on plant communities, selected soil properties, and topography on 31 sites in Lac du Bois Provincial Grasslands Park during May-July 2010.

Because this study is concerned with the potential effects of climate change, sites were chosen on north and south-facing slopes to capture the variation in vegetation and soils most likely to be affected by changes in temperature and soil moisture at the same elevations.

## Project Outcomes

Plant communities were associated with unique environmental properties. For example, the bluebunch wheatgrass/big sage group was associated with more lichen, exposed rock, and compacted soil, while the rough fescue/Kentucky bluegrass group was associated with greater amounts of litter and higher soil fertility.

Stronger plant-soil feedbacks were found on north-facing slopes, while on south-facing slopes the effect of slope angle on heat and desiccation stress was an important factor shaping plant communities.

The highest occurrences of invasive species in the study area were at the higher elevations, likely in response to increasing precipitation, lower temperatures, and higher soil fertility.

In summary:

- The relationship of plant communities and soil properties is highly dependent on slope and aspect.

Dr. Gary Bradfield, MSc student Robert Lee, and Dr. Reg Newman at a Lac du Bois grassland study site. PHOTO: Dr. M. Krzic

- The invasive plant species observed in this study with the highest potential to persist under conditions of future change are Kentucky bluegrass, yellow salsify, and cheatgrass.

- Continued sampling will be important to track changes in the soil, plant communities, and invasive species distributions of Lac du Bois.

## Future Directions

The information gathered during this study can aid grassland managers by adding to current knowledge about the relationships between plant communities, soil properties, and topography, which are important for predicting effects of future climate change and the spread of invasive plant species.•

Project Overview

# Biological Soil Crusts & Nutrient Cycling in Grassland Soils/

Darwyn Coxson, Paul Sandborn & Kasia Caputa

Biological soil crusts are an often underappreciated component of BC's grasslands. Found on the soil surface in areas unoccupied by grasses and other plants, these communities of lichens, mosses, cyanobacteria and algae hold soil particles together, improving the stability of the soil and preventing erosion by wind and water. Soil crusts also improve the fertility of soils by adding carbon via photosynthesis, and nitrogen through the process of biological nitrogen fixation. Any changes in annual temperature and precipitation patterns may have significant impacts on annual rates of nitrogen fixation and the contribution of biological soil crusts to soil nutrient pools.

## Project Outline

This project consisted of two main parts:

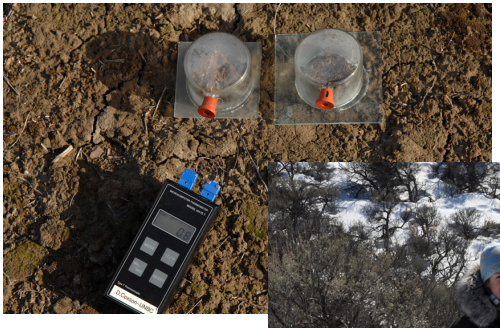
1. Assess the importance of biological soil crusts to soil nutrient status across elevation gradients.

2. Model rates of nitrogen fixation by biological soil crusts during different seasonal periods.

## Methods

We compared the total carbon, nitrogen and mineralizable nitrogen in the crust and underlying soil. Samples were taken at varying elevations in order to assess the effect of temperature and moisture availability on the carbon and nitrogen content of soil crusts. This field work was conducted in Lac du Bois Provincial Park, near Kamloops, B.C.

A significant proportion of yearly physiological activity in Chilcotin biological soil crusts occurs during snowmelt episodes during late winter and early spring.



ABOVE: Rates of nitrogen fixation in biological soil crusts were estimated using acetylene reduction assays in sealed glass cuvettes. RIGHT: Project graduate student Kasia Caputa downloading climate data from field monitoring station.

Soil microclimate (temperature, light and moisture) was measured over a two-year period in an upper and lower elevation grassland in the Chilcotin region of BC.

We collected samples of the biological soil crust from the same area to measure rates of nitrogen fixation. These measurements were done under controlled alterations of temperature, light and moisture find response curves for nitrogen fixation rates against soil microclimate.

## Project Results

• Biological soil crusts are an important source of carbon and nitrogen in grassland soils

• The late winter period appears to be particularly important for nitrogen fixation activity due to the ample availability of moisture from snowmelt.

• Climatic changes that affect moisture availability, particularly during the winter, could have a significant impact on nitrogen inputs by biological soil crusts.

## Future Directions

The nitrogen fixation modelling could be applied to higher elevation soil crust communities and also to carbon cycling by measuring net photosynthesis and dark respiration in soil crusts. •

Project Overview

# Experimental Precipitation Effects on Grasslands/

Lauch Fraser, Justine McCulloch, Anna Sapoznikova & Don Thompson

Understanding the response of grasslands to the combined effects of precipitation changes and grazing pressures as global climate continue to change will facilitate informed management and conservation decisions.

## Project Outline

We asked the following questions:

1. How does changing the season and size of rainfall events affect grassland plant diversity and growth?

2. How does soil carbon (C) change with these rain and grazing treatments and how might this affect soil carbon storage potential for carbon sequestration?

## Methods

Four combinations of hand watering treatments were applied to different frequencies of controlled rainfall manipulations in either the spring or fall. Grazing was simulated by clipping plants.

We measured total plant cover, presence and cover of each species, total growth, soil water and temperature, and soil carbon.

## Project Results

Plant community biomass was reduced with clipping, but the rainfall treatment did not affect biomass or diversity.

An increase in frequency of fall precipitation increased

Rainout shelters are used in Lac du Bois Provincial Park for the controlled manipulation of precipitation treatments. PHOTO: Justine McCulloch.

soil carbon. Clipping (grazing) during fall also increased soil carbon, but only in certain grasslands.

## Future Directions

Basic research on how plant communities may change based on shifting rainfall patterns, and the effects this may have on a host of ecological processes is fundamental to informed land management.

Accounting for changing climate effects on soil, litter, biomass, growth, nutrient cycling and shifting species composition will allow for commercial use of grasslands in the ranching industry while maintaining ecological integrity.

Demonstrating the effectiveness of the rainout shelter following a natural rain event. PHOTO: Justine McCulloch.

Project Overview

# Thermal Habitat use by Northern Pacific Rattlesnakes: a GIS Mapping Approach/

Karl Larsen, John Surgenor & Jessica Gosling



LEFT: Handling a Northern Pacific Rattlesnake in the field using snake tubes. PHOTO: John Surgenor. RIGHT: Northern Pacific Rattlesnake being handled with snake tongs near Penticton BC. PHOTO: Jessica Gosling.

Rattlesnakes in BC have generally been associated with grassland and open Ponderosa Pine ecosystems at low to mid elevations, but forest habitat use has recently been recorded. As rattlesnakes are ectothermic, this habitat selection may be driven by the thermal attributes of the ecosystem.

## Project Outline

The objectives of this study were to:

- Refine and test a thermal mapping model to model summer movements and habitat use of rattlesnakes in the BC Interior
- Explore the ramifications of various climate change scenarios on the conservation of rattlesnakes, using the thermal-mapping model tool.

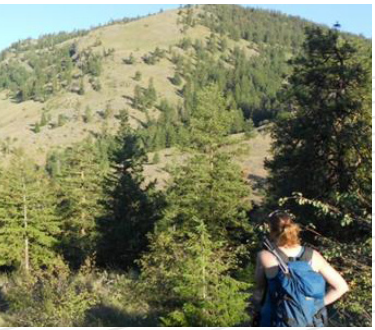
Forest habitat for Northern Pacific rattlesnakes near Penticton BC. PHOTO: Jessica Gosling.

Typical grassland habitat used by rattlesnakes in BC. PHOTO: Jessica Gosling.

## Methods

We used a GIS thermal-landscape model, developed by the Grassland Conservation Council (GCC) to thermal-map the landscapes surrounding a large sample of about 25 dens recorded in the provincial database, using incident solar radiation as a proxy for temperature.

This allowed us to generate predictions on where snakes from these dens will travel in the summer, and whether snakes from specific dens are expected to cross major habitat boundaries or not. Over two years, 35 snakes from 10 dens were captured and implanted with radio-transmitters and temperature data-loggers.



Six study sites were located in the Thompson-Nicola region and four in the Okanagan-Similkameen. Snakes were radio-tracked for the length of their active season and movement, habitat and thermal data were collected for detailed behavioural analysis of these animals.

## Results

- Use of forested habitats by tagged animals occured at seven of the 10 dens, while the snakes from the remaining dens used grassland habitat only. In the Thompson-Nicola regions, we saw consistent behaviours from all the snakes at an individual den . In the Okanagan-Similkameen, some individuals from each den used grassland habitat exclusively, while others travelled to higher elevation forest habitat.

- Outward movements took place from the beginning of May to September. The maximum distance from a den was 3.9km with total movements ranging from 1.5 to 3.9km in the Thompson and 373m to 3.4km in the Okanagan. Snakes began returning to dens as early as the beginning of August, with some remaining kilometres away until September.

- The majority of snakes are using habitats that provide a thermal advantage on both landscape and local scales. There is a fitness advantage to snakes using forest habitat that may be attributed to thermal factors.

Project Overview

# Cattle Methane Emissions

John Church, Doug Veira, Peter Tsigaris, George Penfold, Jon van Hamme, Alan Iwaasa & Allan Raymond

Left: Cows and calves graze in a pasture in Lac du Bois grasslands. Right: Cow being fitted with the halter and PVC yoke used for sample collection. PHOTOS: John Church

Methane (CH4) is a greenhouse gas (GHG) whose atmospheric concentrations have increased dramatically over the last century. Methane released to the atmosphere by domestic ruminant livestock is considered one of the three largest anthropogenic sources. Globally, ruminant livestock emit roughly 80Tg (1 Tg = 10 12 g = 1 million metric ton) of methane per year, accounting for about 20-25 percent of the global anthropogenic CH4 emissions, and roughly 12 percent of the total atmospheric CH4 load. Methane is considered by many to be one of the largest potential contributors to climate change.

## Project Objectives

The purpose of this study was to assist producers to accurately assess greenhouse gas emissions from cattle grazing on crown range land in the central interior of BC, and incorporate this information into a whole system modelling approach to determine the carbon footprint of BC's cattle ranching industry.

This study had two distinct, yet inter-related components:

1. Methane measurements using the SF6 tracer technique from cattle grazing the grasslands of the central interior of British Columbia.
2. A thorough accounting of the environmental impacts of the ranching industry in the grasslands of the central interior of BC through life cycle assessment modeling.

## Project Methods

In the sulphur hexafluoride (SF6) tracer method, a tube containing SF6 gas was inserted into the rumen of the cattle. A halter fitted with a capillary tube was placed on the animal's head and connected to an evacuated sampling canister (PVC yoke). After collecting a daily sample, the yoke is removed, pressurized with nitrogen, and then the methane and SF6 concentrations were determined by gas chromatography.

Six young cows were sampled. The cows had tubes "installed" in the rumen in advance (seven days) of the animals (with calves). The sampling program consisted of four, five-day sampling periods during the grazing season.

## Project Outcomes

The cattle grazing in Lac du Bois Grasslands Park produced approximately 364.06 L/day of CH4 during this study, comparable to the amount observed by other research groups for beef-type animals (Ding et al. 2010).

The six young cows produced more CH4 in the spring vs. the fall grazing period (369.63 vs. 358.50 L/day). We had anticipated more CH4 in the fall as the digestibility of the plants begins to drop off. The increase in CH4 in the spring may be attributable to the metabolic stress of lactation, which often necessitates a dramatic increase in feed consumption. The cows were likely at peak lactation during the spring; whereas the metabolic demand from the nursing calves would have decreased in the fall.

## Future Directions

This research has provided significant insight into the environmental footprint of cattle production on BC rangelands from an emissions perspective. While beef cattle do produce greenhouse gas emissions, especially from the enteric CH4 produced by the mature beef cows as measured empirically in this study, grasslands of the central interior have huge potential to offset those emissions through carbon sequestration. The key outcome from this research was to provide the ranching community with insight with respect to their carbon footprint; to pinpoint the sources of greenhouse gas emissions from their operations, and to provide the information enabling them to effectively add value to their products by marketing and branding them as healthy, environmentally-friendly alternatives.•

Project Overview

# Managing Rangelands for Carbon Storage/

Bill Harrower, Lauch Fraser, Cameron Carlyle, Peter deKoning & Amber Cowie

Ranchers are the stewards of much of British Columbia's grasslands, and maintaining economically viable ranches is essential in maintaining British Columbia's grassland ecosystems. Using carbon trading and offset programs to develop new revenue sources for ranchers may help alleviate economic pressures ranchers currently face, allow for improved flexible land management practices that adapt and withstand climate fluctuations, and maintain many of the biological, cultural, and aesthetic values our grasslands provide for generations to come.

## Project Outline

In this project we explore the viability of a carbon offset program in British Columbia's grasslands, and attempt to outline a path to achieving such a program.

We focus on the following objectives:

1) Describe what a carbon offset scheme could look like; following from previous examples and existing infrastructure;

2) Document carbon stores in different grassland types in a key focus region of southern Interior of British Columbia; using 3 hypothetical examples linked directly to grazing ecology.

3) Estimate the economic potential for carbon sequestration in focal regions; is the work required to develop a program worthwhile?

**Table 1.** Monetary value of Thompson-Nicola carbon stores if a 5% increase in sequestration occurred with a change in grazing management.

| Grassland Type | Total Carbon (million $) | Carbon/ha ($) |
|---|---|---|
| Upper Grasslands | 1.1 - 8.3 | 7.64 – 60.12 |
| Middle Grasslands | 0.4 - 3.2 | 9.65 – 75.92 |
| Lower Grassland | 0.6 - 4.5 | 10.22 – 80.35 |
| Total Value | 2.0 - 16.1 | 9.17 – 72.13 |

## Project Outcomes

The grasslands of the Thompson-Nicola contain, on average, 15.79 Mg of elemental carbon per hectare (C/ha). Lower grasslands hold 18.84 Mg C/ha, more than both the upper and middle grasslands.

Though upper grasslands hold less C/ha than lower grasslands, they constitute approximately 60% of grasslands, and represent 55% of total carbon stored in all grasslands of the region.

High abundance of sagebrush in the lower grasslands make for large stores of aboveground carbon, making carbon storage in the lower grasslands higher than both middle and upper elevation grasslands. However, apart from sage removal grazing management is unlikely to impact sagebrush carbon pools significantly.

## Future Directions

| | |
|---|---|
| **Key Research Needs** | **We cannot manage grassland for carbon without data, the following data are required in order of decreasing importance:**<br><br>**1) What is the size of different carbon pools in different grassland types across the province?**<br>**2) How do different grassland types sequester carbon under different grazing intensities, and less importantly different seasonal grazing regimes?**<br>**3) What is the extent of nitrous oxide emissions from cattle on pasture and winter feed operations, and how much methane do cows produce on different types and conditions of pasture?**<br>**4) How do different timing and intensity of rain and differing moisture regimes from changes in snowmelt impact site productivity and carbon sequestration grazed pasture.**<br><br>**Points 1-3 above will likely be required in the development of offset verification and validation protocols.** |

Project Overview

# Planning for Climate Change in Range Management/

Reg Newman, Rick Tucker, Russ Walton & Brian Wallace

Field workshop in Lac du Bois Provincial Park near Kamloops, BC.

The objective of this project was to develop strategies that will assist range managers in dealing with a set of future conditions that may result from climate change. The work was focused on a single range management unit so that the results could be directly applied to operational management.

## Our Project

The project consisted of three components:

- Climate change modelling
- Impact assessment
- Adaptation strategies

## Our Methods

Previous climate change modelling work for forests was adapted to determine the impacts of climate change on range management. The potential impacts of climate change on range vegetation were examined by:

- assessment by a panel of specialists using field and office-based methods
- development of a predictive forage model.

Based on our detailed considerations we developed administrative and legislative options and provided guidance for developing forward-looking operational plans for adapting to a number of future climate change scenarios and associated impacts.

## Project Outcomes

Key strategies developed:

• Maintain an aggressive weed control program against high priority weeds.

• Start the process of reducing AUM allocation for pastures where declines in forage supply due to climate change can be verified.

• Start the process of increasing AUM allocation for pastures where increases in forage supply due to climate change can be verified.

• Develop a monitoring program to detect forage supply changes resulting from climate change.

• Adopt livestock management regulations and practices adaptable to low or highly variable forage supply.

## Future Directions

The successful adaptation of range management to climate change in BC will require:

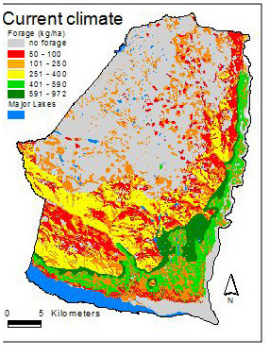
• stakeholders understand and agree on the extent and impacts of climate change;

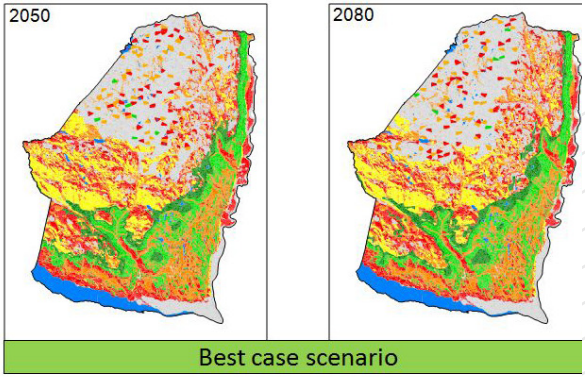
• a revised expectation for rangelands

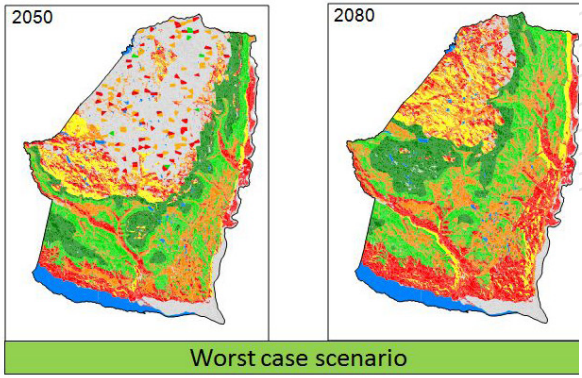
• range managers at all levels to develop a culture that recognizes and expects constantly changing abiotic and biotic environments;

• range managers to increase their awareness of environmental changes through observation and quantitative monitoring; and

• plans that consider and prepare for a number of future possibilities are developed. •




**Predicted forage potential for current and future climates in the Tranquille Stock Range area.**

Predicted forage potential for current and future climates in the Tranquille Stock Range area.

# Have Questions?

P: 250.377.6135

E: climatechangeandbcrange@gmail.com

website: climatechangeandbcrange.net

Project Lead:
Lauchlan H. Fraser, PhD
Professor & Canada Research Chair in Community and Ecosystem Ecology
Department of Natural Resource Sciences and Biological Sciences
Thompson Rivers University
900 McGill Road, PO Box 3010
Kamloops, BC
Canada V2C 5N3
lfraser@tru.ca