

## YEAR ONE PROGRESS REPORT

### Future Forest Ecosystems Scientific Council

#### 007- Fraser: Managing for the ecological and socioeconomic effects of climate change on BC rangelands

##### RESEARCH PROCESS

Our project includes ten 'teams'. Each team has objectives that feed into the overall project goal. The P.I. (Lauch Fraser) organized quarterly meetings (four times per year) for all the members of the project (all ten teams) to meet and share progress and to strategize future steps.

##### RESEARCH PROGRESS

**Team 1:** L Fraser, D Thompson, J McCulloch, A Sapozhnikova

**Objective:** 1) How does variation in seasonality and frequency of precipitation affect grassland community diversity and productivity? 2) How do precipitation patterns and grazing interact and affect grassland community diversity and productivity? 3) How do precipitation patterns and grazing interact and affect carbon storage and sequestration?

**Progress to date:** In April 2010, cattle exclosures were erected at each site. Plots were set up and treatments started the first week of May 2010. Watering treatments manipulated the season and frequency of rainfall. All treatment plots were covered with a rain shade (RS) in both spring (May-June) and fall (September-October) and all water applied by hand watering. Four combinations of watering treatments were applied: 1) Spring watering applied every week with fall RS; 2) Spring watering applied every four weeks with fall RS; 3) Fall watering applied every week with spring RS; 4) Fall watering applied every four weeks with spring RS. Amounts were increased by 50% of the historical 30-year average for the month of watering. Two types of control plots will be included in each block. One was unmanipulated, the other had a RS installed with vertical slits cut 10cm apart. This allowed ambient rainfall to reach the plot, while controlling for unintended effects the RS may have had on light interception, and possibly air flow and humidity, on the plots. Grazing was simulated by clipping biomass in the plots to 5 cm above the soil or litter surface. All treatments were applied in a fully factorial design, creating 12 different treatment plots in a block. Blocks were replicated six times at each of three sites along the productivity gradient in the grassland.

**Measurements:** Percent cover estimates of each plant species. Soil moisture and temperature measured using soil probes left in place over the entire season, logging measurements every half hour. The soil moisture probes (Soil Moisture Smart Sensor, S-SMB-M005 using an ECH<sub>2</sub>O<sup>®</sup> Dielectric Aquameter probe, Decagon Devices, Inc.) were 10 cm long, and were placed vertically into the soil. Plant-available nitrogen (N) was measured using Plant Root Simulator (PRS)<sup>™</sup>-probes (Western Ag Innovations Inc.). The probes remained in place for two months at three time periods (1-May and June; 2-July and August; 3-September and October). Soil sampling was carried out using a soil corer with 5 cm diameter. The analysis of collected samples for soil organic carbon in the laboratory was carried out using the Exeter Analytical CE440 Elemental Analyzer. Soil respiration was measured with a transportable infrared gas analyzer.

**Team 2:** R. Newman, B. Wallace, R. Tucker

**Objective:** For a selected case study area (as demarked by an individual stock range), provide a projection of changes in: vegetation (native and non-native invasives) and stock water under climate changes predicted by the climate model, ClimateBC. This will be undertaken for four scenarios predicting the best and worse cases for the next 40 and 70 years based on the best available information (including data published, unpublished and collected as a part of the proposed project). Using these projections, develop strategic Range Use Plans, Range Stewardship Plans, and range management strategic documents which adapt management to future conditions.

**Progress to date:** Fifteen vegetation and soil plots characterizing grassland and open forest were sampled during the summer 2010 (some of these in collaboration with Team 4). Soil moisture probes at depths to ~ 80 cm installed spring/summer 2010 at two locations in the lower grasslands. Field assessments of potential plant

species shifts for two climate change scenarios at 40 and 70 years were completed within BEC site series by the plant ecology working group (7 member team). Some progress made on collecting published data/reports for inclusion in the modelling component.

Digital base maps of the Tranquille stock range case study area have been completed in both vector and raster format, including existing projected BEC shift layers for 40 and 70 years into the future.

**Team 3:** Sanborn, Coxson, Caputa

**Objective:** Assess and quantify potential climate-related changes in composition and function of biological soil crusts in central and southern interior grasslands, using trends along elevation gradients as a proxy for climate.

**Progress to date:** A major focus of our work on the response of nitrogen fixation in BSC communities is the assessment of seasonal response to changing environmental conditions. We have installed 2 field climate stations, one in the lower elevation sage-steppe grasslands at Farwell Canyon. This was installed in late fall 2009, giving us critical snowmelt measurements in the winter of 2010. A second higher elevation climate station was installed approximately 25 km west of Becher's Prairie area in June 2010. Both stations feature an array of soil surface fine-wire thermocouples, Li-Cor quantum sensors, custom built lichen impedance clip sensors to measure BSC hydration status, and Decagon soil moisture probes. Soil surface microclimate data from these stations will be used to assess when major periods of physiological activity occur in BSC communities. The assessment of nitrogen fixation potential using acetylene reduction assays (ARA) occurred in both laboratory and field settings. Our field work in 2010 concentrated in the immediate snowmelt period, with field ARA assessments in March 2010 providing data on BSC response to diel freeze/thaw cycles. We were unable to complete field assessments of ARA response in the summer of 2010 at Farwell Canyon due to prolonged drought conditions and access restrictions resulting from forest fire hazard. At Lac du Bois, we sampled crusts and the underlying mineral soil at 50 locations on an elevation transect from ~ 400 to 900 m elevation. Preliminary data displayed a consistent pattern of enrichment of total C, total N, and mineralizable (i.e. potentially plant-available) N in crusts relative to soil across this elevation range. The results also show a significant effect of elevation on crust and soil nutrients. Analysis of these samples for <sup>15</sup>N natural abundance is currently in progress and will indicate how much of the total nitrogen content is due to atmospheric fixation by the BSC.

**Team 4:** Gary Bradfield (UBC Botany), Maja Krzic(UBC Soil Science), Robbie Lee (MSc student)

**Objectives:** 1) Quantify the strength of relationships between soils, climate, and topography of study sites and (a) native:exotic plant richness, (b) individual exotic plant species of highest invasion concern (c) overall plant community composition; 2) Predict the movement of key exotic plant species under a climate change scenario using current climate change models and data from Objective 1

**Progress to date:** Field sampling and measurement was done between May 3 and July 28, 2010 in the bunchgrass zone of Lac du Bois Provincial Park, north of Kamloops, BC. A total of 38 sites, ranging in elevation from 372 to 983 m, were included in this study. During the 2010 growing season, we sampled soil and vegetation on 31 sites, out of which 15 were in the Lower grasslands, 15 in the Middle grasslands, and one site was in the Upper grassland. The sites were selected through a stratified-random procedure. An additional seven sites in the Upper grasslands, sampled by Dr. Reg Newman in 2006 and 2007, were also included into our study. These study sites were restricted by aspect and classified as South Steep slope, South Moderate slope, or North Slope. North vs. South slope will be used as a surrogate for climate change, since north slopes experience a slightly wetter and cooler climate than south slopes at the same elevation.

**Measurements:** On each site, we identified a representative area 15 by 30 m in size (termed a "plot"), within which we laid out four 30-m long transects. Along each of the four transects we estimated percent cover of all vascular plant species and ground cover classes for 10 Daubenmire frames for a total of 40 frames per plot. We performed a "walkabout" by dividing the plot and a buffer around it into equal sized rectangles and recorded presence/absence of exotic plant species to get a frequency measure for the site. In addition, we also recorded presence of native species not encountered in Daubenmire frames in order to find total site richness. On each site, soil samples were collected along four transects for aggregate stability, total C, total N, available P, pH,

texture, and water content determination. These samples were collected from 0-7.5 cm depth. Soil sampling was done between the vegetation measurements so that there was no interference. On two of the four soil sampling transects, soil samples for bulk density determination were obtained from 0-7.5 cm depth by using a double-cylinder drop-hammer sampler and a 7.3-cm-diameter by 7.5-cm-deep core (331.35 cm<sup>3</sup> in volume).

**Team 5:** K Larsen, J Gossling, I Mackenzie, J Surgenor

**Objectives:** 1. Refine and test a thermal mapping model's ability to predict current summer movements and habitat use of rattlesnakes in the BC Interior. 2. Explore the ramifications of various climate change scenarios on the conservation of rattlesnakes, using the thermal-mapping model tool.

**Progress to date:** Using the GIS thermal-landscape model, developed by the Grassland Conservation Council (GCC), we will thermal-map the landscapes surrounding a large sample (approx. 25) of dens recorded in the provincial database. The key variables in our model are the ruggedness index (a proxy for rockiness), solar radiation index, and to a lesser extent, slope and aspect. Other variables include vegetation community zones and GCC's grasslands GIS. This will allow us to generate predictions on where snakes from these dens will travel in the summer, and whether snakes from specific dens are expected or not expected to cross major habitat boundaries. In April 2010, we captured 16 male snakes from six dens in the Thompson-Nicola. The snakes were implanted with radio-transmitters and iButtons, and then released at their dens. One more snake was captured and implanted with a radio-transmitter in mid June, to bring the total number of snakes to 17, from six dens. Over the course of the field season, approximately 20 additional snakes (both male and female) have been processed and implanted with identification tags. These snakes were monitored through incidental encounters while tracking radio-tagged snakes, and data obtained will provide anecdotal information on movement patterns of females. Weekly tracking of radio-tagged animals continued until the end of September. The snakes were then re-captured to have their radio-transmitters and iButtons removed before being released for hibernation.

**Team 6:** Fraser, Tucker, Jennings, Coupe

**Objectives:** Provide range expertise

**Progress to date:** All teams, and in particular teams 1,2,3,4,8, have relied on the range experts.

**Team 7:** Church, Veira, Tsigaris, Penfold, Van Hamme, Iwaasa, Raymond, Archambault, Thompson, Moote

**Objective:** 1) Developing life cycle assessment modeling to determine the impact of climate change on cattle production from rangelands.

**Progress to date:** In May and October 2010, methane measurements were taken from 6 young mature cows from both the bachelor and prudence study sites within the Lac Dubois grasslands study area during four one week periods using the sulfur hexafluoride tracer technique (see below). Representative samples were collected from the plant communities as well. We switched to cows from young steers upon the discovery that within the beef production cycle, the cow-calf system accounted for about 80% of total GHG emissions and the feedlot system for only 20% (Beauchemin et al 2010). Enteric CH<sub>4</sub> has been estimated in Alberta to be the largest contributing source of GHG, accounting for about 60% of total emissions. About 84% of enteric CH<sub>4</sub> in the Alberta study was from the cow-calf herd, mostly from mature cows, hence the switch from steers to cows. Analytical laboratory methods were developed on the gas chromatograph during the summer in order to analyze the samples collected for both methane and sulfur hexafluoride. The last samples to be collected for the fall will commence the week of October 25, 2010. A modelling workshop was held at TRU in the spring of 2010, and attended by J Church, P Tsigaris and A Raymond (graduate student recruited to work on the project). In addition, three members of the team attended a second modelling workshop at the Greenhouse Gas and Animal Agriculture Workshop held in Banff on October 3-8, 2010. We have decided to use the HOLOS model developed by Agriculture and Agri-Food Canada to do the life cycle assessment of the greenhouse gas emission from beef production from BC's grasslands. The HOLOS model is based on Intergovernmental Panel on climate change methodology, modified for Canadian conditions and farm scale.

**Team 8:** L Fraser, W Gardner, R Androkovich, M Mahbobi, M Cox

**Objectives:** (1) To determine whether B.C. ranchers have observed changes on the rangeland they own/lease/rent over the last 20 years; (2) to determine whether ranchers regard any of the changes as being a direct consequence of climate change; (3) to determine whether ranchers have altered management practices as a consequence of changes on the rangeland they own/lease/rent; and (4) to determine the extent to which the perceived changes have affected the profitability of ranching.

**Progress to date:** The survey has been developed and vetted by the BC Cattlemen's Association (BCCA) and sent to Human Ethics Committee at TRU for approval.

**Team 9:** Bob Moody, Ian Mackenzie

**Objectives:** Establish a framework for full cost accounting of natural capital and ecological goods and services provided by grasslands and rangelands, with particular emphasis on carbon marketing systems.

**Progress to date:** Familiarization with InVest program for calculation of natural capital. Review and development of GIS maps and data on land status (provincial crown / private / ALR) to help determine suitable areas for a pilot study.

**Team 10:** Horton, Liggins, Zabek, Gardner

**Objectives:** Facilitate extension and outreach by (1) coordinating and providing extension expertise for teams #1-9; (2) fostering communications with client groups; and, (3) partnering in the development of web, print and workshop communications.

**Research progress:** Provided input at all four project update meetings. Development of guidelines for creating fact sheets for each team to enhance communication as results become available.

## COLLABORATION

- A field based workshop (at Riske Creek) was conducted with Dr. Janet Marsh in June 2010, focusing on biological soil crust composition in the Chilcotin grassland elevational transect. We have made further collections in both the Farwell Canyon - Becher's Prairie area and at Lac du Bois. These are being analyzed for soil crust community composition this fall and winter. We additionally plan a second field workshop in spring 2011 with Dr. Marsh.
- We submitted a large, multidisciplinary grant to the International Development Research Council to build on the FFESC project, with collaborators in China and Argentina. Unfortunately, the grant application was unsuccessful but the collaborations were useful and Fraser was able to travel to China to share and discuss the objectives of the FFESC project.
- We submitted a large grant to the Innovative Approaches Program through Agriculture and Agri-Foods Canada, which is pending. The grant is designed to build on the FFESC project and focuses on carbon offsets in rangeland.

## COMMUNICATION

- Meetings with the Pacific Carbon Trust and SunOne Solutions regarding if and how to do a carbon offset pilot project in BC grasslands.
- Meetings with Living Carbon Ltd / Land Trust Alliance and Frederik Vroom regarding if and how to do soil carbon offsets in BC grasslands
- Meetings with MOFR Research Branch regarding how to map soil carbon using existing datasets and Digital Elevation Models (DEMs).
- Short presentations by Team 1,5,7, and 8 were given on September 16, 2010 to a Chinese grasslands delegation at TRU.
- A short presentation by Team 4 was given on October 18, 2010 in BOTA 406 - plant ecology course at UBC.