

## **RM-CESU - Project Completion Report, FY 05**

**Project Title: Elk impacts on alpine willow communities and the development of a protocol for assessing alpine tundra vegetation**

**Park: ROMO**

**Funding Source: \$29,999 from Rocky Mountain National Park, \$8,000 from Rocky Mountains CESU, and \$10,000 from Rocky Mountain Inventory & Monitoring Network**

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**Student Participants: 1**

### **Project Description:**

Ecologists have invested a large effort in understanding the effects of ungulates on plant communities. In particular, impacts of elk on mid-elevation montane grasslands and shrub communities have been studied intensely in Rocky Mountain National Park. In contrast, the impacts of elk on subalpine and alpine tundra communities of the park remain poorly understood. The purpose of this project is to understand impacts of grazing and browsing by elk on high elevation plant communities and how those impacts may shape the hydrologic regime of willow stands and extend through food webs to influence other communities and species of wildlife.

Two research hypotheses on the effects of elk populations on willow communities at high elevations will be evaluated in this project. 1) Browsing and grazing by elk on high elevation plant communities suppresses the height of willows. 2) Height suppression drives other changes in these communities including reductions in snow distribution and depth, reductions in soil water recharge, and shifts in the composition of herbaceous plant communities and willow biomass. To this the following monitoring hypothesis was added: the research techniques proposed here can be adapted for use in long-term monitoring of the status of vegetation and soil conditions and herbivore effects on vegetation and soil conditions in alpine systems. The monitoring hypothesis is a working hypothesis, rather than a testable hypothesis, but evidence as to the effectiveness of the techniques for change detection is desired.

To test the research hypotheses, an observational study of comparable sites that differ only in elk density was initially proposed prior to the addition of the monitoring component of the project. This project has been modified to better suit developing a monitoring protocol for alpine areas of the national parks and to better evaluate the ecological condition of willow communities within Rocky Mountain National Park (RMNP) across aspects and elevations greater than 11,000 ft, and on both sides of the continental divide. In particular, a stratified-random sampling design will be used to

select a set of sites throughout RMNP for an extensive study of the willow communities, including the effect of elk on these communities. Further details on this extensive study follow as a component of the project results, since this approach leads into developing a monitoring protocol. The extensive study of RMNP willow communities will be conducted during the summer of 2006.

A clipping experiment, a manipulative experiment to evaluate the effects of elk browsing on willow growth, site conditions, and vegetation structure will also be conducted in the winter/spring of 2006. We will identify paired areas with similar willow heights and snow depths. We will then clip the willows in one paired plot with hand clippers. A literature review of elk browsing on willows has been initiated to inform the protocol for how to conduct the vegetation removal to simulate elk browsing. We will conduct three of these small clipping experiments. We will then measure the snow depths and water equivalents in the spring of 2006 and soil moisture during the summer of 2006 in the paired plots to quantify if snow and soil moisture have significantly changed due to the simulated browsing. The compensatory response of the vegetation to the simulated browsing will be measured during the summer of 2006, and if possible a second set of measurements of the snowpack will be made the following winter.

This study will be conducted by Research Scientists David Cooper, Heidi Steltzer, and Tom Hobbs (all from Colorado State University). Heidi Steltzer is replacing Rodney Chimner on the project, as Rodney accepted a new position in Michigan. Heidi's research expertise is well-matched to this project. Her expertise includes studies on vegetation and soil in the alpine tundra of Colorado and Alaska generally aimed at characterizing plant-soil interactions and ecosystem function. She has also investigated the response of willows to increased summer precipitation and temperature in the Arctic. Because of the timing of this shift in personnel, only reconnaissance work could be completed in the field prior to the onset of winter. Planning is underway to initiate the clipping experiment this winter/spring, when we expect browsing by elk is most likely to occur.

### **Project Results:**

Reconnaissance work within RMNP this August suggested that distinguishing elk browse from wind damage as causes of vegetation loss and stem dieback may be difficult late in the growing season. Heidi was assisted by Danille Bilyeu, a graduate student at Colorado State University, in evaluating whether elk browse could be determined by observing the stems of willows at three sites within the park. Danielle has been working on her dissertation research in Yellowstone National Park for the past 4 years examining the effect of elk browsing on willows in lower elevation river valleys. At the two higher elevation sites in RMNP more typical of alpine vegetation, elk presence was noted through the abundance of pellets, but no clear evidence of browsing could be seen. Stem die-back below the Gore Range Overlook on Trail Ridge Road was high, but could just as likely have resulted from wind damage. At the lower elevation site more typical of subalpine vegetation, no stem die-back was observed, and there was no evidence of willow browsing although pellets were present.

These observations along with the addition of the monitoring component of the project has led us to revise our observational study to conduct an extensive study of the ecological condition of willow communities across RMNP rather than an intensive study

at only a few sites that differ in elk density. A set of sites will be selected randomly, but will be stratified to ensure sites are chosen throughout the park with different elevations and aspects represented. Additionally, key sites of interest to the park, because of their high visitation will be included after consulting with park staff on which sites would best fit this description. Two questions will be addressed: Where are willows present at high elevations in RMNP? And what percentage of the willow communities is expanding, stable, or declining? The balance between the regeneration of new stems and stem die-back will determine how a willow community is classified. Future monitoring sites can then be selected from among these sites to monitor a change in the condition of willow stands (i.e. if previously declining stands shift to stable stands) and for new colonization. We expect that willow may be able to establish at some sites that currently do not have willow communities following disturbance and as the climate warms.

The standard operating protocol (SOP) that will be developed from this approach will include characterizing the vegetation, elk activity, and site environmental conditions. The PIs and ROMN staff will work together to integrate the willow sampling procedures described below with other terrestrial system monitoring both within the ROMN and in other networks/programs. Characterizing the willow communities will focus on measuring their aerial extent and structure, including the density, biomass, and height of live and dead stems. Live stem production will also be measured. Willow regeneration or the production of new stems at the ground-level will be characterized at each site. Similarly, stem die-back, stems that no longer contain any live stem above ground-level, will also be assessed.

The presence and impact of elk on the willow communities will be assessed through counting pellets, observing stems for browse points, and marking stems for site revisits. We expect that elk browse likely occurs in winter and spring in the alpine, when little other forage is available to elk that remain at high elevations. Observing elk browse may be improved by making observations during these times, measuring and marking stems, and returning to a site to note any changes.

Site environmental conditions will be characterized to determine what conditions are necessary to support willow communities, including topography and soil structure, which in addition to the structure of the willow communities influence the hydrologic regime. As needed to develop the SOP for alpine areas, a subset of sites will be selected to characterize ecosystem functions, such as carbon cycling and soil characteristics.

Our goal is to provide RMNP with an understanding of whether elk are impacting willow communities and the effect of browsing on the alpine/subalpine willow communities of RMNP. In addition, we will use our data to develop a protocol for assessing alpine tundra vegetation. We will work closely with the NPS Rocky Mountain I&M program team to choose the right protocol development approach, and use data on alpine vegetation types, as well as willow communities to create this protocol. We understand that NPS is interested in an alpine assessment protocol that would be useful not only for RMNP, but also for national parks elsewhere in the Rocky Mountains, as well as Cascade and Sierra Nevada Ranges.

Both David and Heidi participated in a workshop this fall to bring the project development up to date and network with others working on related projects. David attended the fall workshop of the western NPS I&M networks aimed at developing a monitoring protocol for alpine ecosystems. Heidi attended a snow system science

workshop this fall that was organized by the Center for Snow and Avalanche Studies (Silverton, CO). This workshop provided an opportunity to learn more about characterizing snow accumulation and current perspectives of how snowfall in the Rocky Mountain West is expected to change as climate changes, and to present a summary of the effect of vegetation on snow accumulation and soil nutrient dynamics under the snowpack.

**Follow-up of this Project** – project still in progress for one and a half more years.

**Publications, other reports expected/ with dates:**

- Report to RMNP biologists and management staff describing the results of the elk herbivory experiments detailing the connections between elk, willow, snow depth, soil water content, herbaceous vegetation, and system function. July 2007. A manuscript on the extensive study of willow communities across the park and a manuscript on the results of the clipping experiment will be submitted for publication in an appropriate ecological journal.
- Presentation to RMNP (and ROMN) biologists and management staff describing the results of the elk herbivory experiments detailing the connections between elk, willow, snow depth, soil water content, herbaceous vegetation, and system function. July 2007.
- Draft protocols for monitoring vegetation, herbivory, and related soil and hydrologic conditions, including a literature review of other alpine monitoring programs. Protocols will be based on the research in RMNP, but should be generally applicable for alpine regions of ROMN units (esp. Glacier, Great Sand Dunes, and Rocky Mountain National Parks). The proposed monitoring methods should be able to detect community and ecosystem changes due to climate change, atmospheric deposition, herbivory, or other stressors/drivers. The goal of SOPs is to synthesize and integrate the sample design from this project with monitoring of other systems and monitoring alpine monitoring of other parks. July 2007.