

Project Summary
Rocky Mountains Cooperative Ecosystem Studies Unit

Project Title: Willow Decline in Rocky Mountain National Park: Examining the Interactions of Drought, Ungulate Browsing, Sapsuckers, and *Cytospora* Fungal Infection

Discipline: Natural
Type of Project: Research
Funding Agency: National Park Service
Other Partners/Cooperators: Colorado State University
Effective Dates: 3/15/2010- 6/30/2013
Funding Amount: \$37,858

Investigators and Agency Representative:

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Project Abstract: CSU will examine two primary questions:

- I. When did the dieback occur and how widespread is dieback in RMNP?**
- II. What factors influence whether a willow stem will die due to *Cytospora* infection?**

I. To determine when the dieback of large stems occurred, we developed a novel aging technique. When a willow stem segment dies, apical dominance of the main stem is removed triggering epicormic (lateral) branching at a point just below the dieback on each willow stem. Many tall and largely dead willow stems have live epicormic branches created when the main stem died. The age of the epicormic branches likely indicates the year the main stem dieback was initiated. CSU will collect a random sample of approximately 100 stems and count growth rings on epicormic branches using standard methods to determine the year of dieback. This technique can be used to age willow stem death, and possibly other shrub species, in many Rocky Mountain region parks.

In addition to the ground based sampling, we will use aerial photographs to determine the timing and spatial scale of willow dieback (Peinetti et al. 2002 used similar methods in Moraine Park). Historical vertical air photos from 1969, 1989, 1999, 2001, 2005, 2007 and 2009 will be used to identify patterns of beaver occupation in the study areas, as well as willow population changes due to beaver absence. Park-wide vegetation maps will be used to help determine willow dominated sites. Willow polygons will be delineated and changes in spatial extent will be compared through time.

The spatial extent of the dieback throughout RMNP will be done using a spatially balanced random survey, Reversed Randomized Quadrant-Recursive Raster (RRQRR), of willow polygons. At these sites a large sample of willows, and their current condition, dieback, and presence/absence of *Cytospora* spp. will be documented.

II. To examine willow/fungus dynamics, CSU implemented field experiments during the summer of 2009. First, utilizing three exclosures originally established in 1998 to prevent moose and elk browsing of selected areas, we randomly located six plots within and six outside (within 50m) of each exclosure. A well at each plot center serves as a groundwater depth monitoring location. Six randomly selected willow plants were tagged surrounding each well. On each plant the number of live and dead stems, height of tallest live and dead stems, length and width of live and dead canopies, and production were measured. Ground water levels were measured biweekly to determine if water depth was related to the patterns of willow growth, dieback and fungus infection. Soil temperature sensors were installed at 10 cm depth in a random subset of sites (12 sites; 2 inside and 2 outside each of 3 exclosures).

A goal of this analysis is to determine whether soil water availability, interacting with browsing intensity and sapsucker wounding, controls the rate of fungal infection. CSU will place bird netting over randomly selected willows to remove the potential for sapsucker wounding. Physiological measures will include twig xylem pressure potential (Ψ_{xp}) made using a Scholander-type pressure bomb to determine water stress levels in study plants at both pre-dawn (0:00 to 5:00) and mid-day (12:00 to 16:00) time periods. These will serve to correlate soil moisture levels with plant water stress levels. Depth to ground water will be recorded in monitoring wells near each study willow. A comparison of xylem pressure potentials during the growing season will be used to determine thresholds of stems with varying depth to groundwater are under water stress. CSU will also measure production and new stem growth to examine differences in stressed plants.

CSU will quantify the effects of sapsucker wounds on the rate of willow stem fungal infection by analyzing 59 willow stems that were damaged by sapsuckers, and then tagged with unique numbers,

during 2009. We will revisit these stems in 2010 and subsequent growing seasons to document their fate. CSU will measure stem xylem pressure potential on sapsucker stems wounded in 2010 and the netted controls to determine whether the sapsucker is girdling the stem, subsequently killing it, or, if the sapsucker is providing a point of entry for the fungus that eventually kills the stem. CSU will monitor soil moisture and ground water levels.

CSU will also implement a factorial greenhouse experiment, with three water table levels, wounding, and inoculation with *Cytospora*. This will allow us to isolate some of the stressors and develop stress threshold levels. CSU will analyze rooted willow stems grown in pots under three groundwater level conditions (high, moderate and low groundwater levels based upon field measures made during 2009) and wounding effects. CSU will then inoculate a subset of wounded stems across the water table gradient. This greenhouse experiment will allow us to determine the role of water availability as an environmental stressor that interacts with disturbance to influence the fate of willow stems.

Outcomes with Completion Dates:

- Interim reports due December 15, 2010 and December 15, 2011
- Report to RMNP biologists and management staff describing the spatial scale of the willow dieback, as well as results of the willow/fungus experiments detailing the connections between ungulate browsing, sapsucker wounding, soil water availability, groundwater depth, and fungal infection. A manuscript covering the results of this experiment will be submitted for publication in a peer reviewed ecological journal. Expected completion date for dissertation and PhD is December 2012.
- Executive summary of findings (can be included as preface to report) due December 2012.
- Presentation to RMNP (and ROMN) biologists and management staff on the results of the willow/fungus experiments detailing the connections between ungulate browsing, sapsucker wounding, soil water availability, groundwater depth, and fungal infection.

Keywords: willows, ungulate browsing, sapsucker wounding, soil water availability, groundwater depth, fungal infection, Rocky Mountain National Park, Colorado State University