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Investigations of Mountain Mahogany Establishment

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Introduction and Objectives

Rangeland restoration requires the successful establishment of vegetation propagated from seed. We seek to understand the factors that contribute to successful restoration of the shrub True Mountain Mahogany, *Cercocarpus montanus* H.B.K. (Rosaceae). We are investigating the effects of geographic origin, soil factors, and planting properties on seed germination and seedling establishment of this species in a transplant study established along a north-south transect from Wyoming to New Mexico. Results will contribute to the management of mountain mahogany shrublands by identifying the radius for collection of seed sources and environmental factors that are most likely to result in revegetation success.

Methods

Study Species

Mountain mahogany is a woody species that occurs from South Dakota to New Mexico, and western Oklahoma to western Utah. There are three to four varieties recognized, the most widespread being *C. montanus* var. *montanus* (Heuvel, 2002). Nitrogen fixing bacteria from the genus *Frankia* infect the roots of *Cercocarpus*, and provide their host and the surrounding soil with nitrogen (Baker & Schwintzer, 1990). The flowers are apetalous, with a tubular calyx and numerous stamens. The fruit is an achene (one seeded, dry indehiscent fruit) and the sepals and stigma are persistent. The style elongates and enlarges and serves as a dispersal mechanism (Russell & Schupp, 1998) for the seed which earned it the Greek name “Cerco-carpus,” meaning “tailed-fruit” (Figure 2).

Study Locations

We have chosen four locations across the range of *C. montanus* that represent distinct ecoregions (Bailey et al., 1994). The most northern study location is near Laramie, WY on Mountain Cement's property where we have set up two different plots on an undisturbed and disturbed site. The second location is in Lyons, CO on Hall Ranch managed by Boulder County Parks & Open Space. The third location is in Manitou Experimental Forest near Woodland Park, CO managed by the Forest Service. The fourth and most southern transplant is near Mora, NM at the John Harrington Forestry Research Facility managed by the University of New Mexico (Figure 3). Seeds and fresh leaf tissue (germplasm) were collected in the summer and fall of 2013, representing a significant portion of mountain mahogany's range (Figure 3).

Reciprocal Transplant

In Laramie, Mora, and Manitou we have established one transplant plot (common garden) containing 1500 seeds from 25 source populations. Each plot consists of three blocks, or randomized replicates, containing 500 seeds each. In Laramie, we established an additional plot on a disturbed site for comparison of the seed sources in a reclamation setting. In Lyons, because we wanted to minimize disturbance to the existing native vegetation, we established six smaller blocks, rather than three, each containing 250 seeds. While the order and design is modified in Lyons, the total number of seeds and seed sources remain the same. In all locations each block is planted in jute netting for the first season to prevent erosion. The location of each individual seed is marked with a plastic toothpick, and seeds were planted in organized 30 cm^2 cells to help relocate seeds and reduce plant resource competition.

In the late spring through early fall of 2014 and 2015 each plot will be censused for germination, survival and growth rate. In addition, 10 greenhouse grown seedlings per seed source (for a total of 250 seedlings per site) will be planted in the remaining plot space during the spring of 2014. Seed germination rates are often low (Rosner et al., 2003), and the study of seedlings will allow for tracking of plant growth beyond the germination bottleneck.

Non-Destructive Measure of Biomass

A non-destructive measure of biomass is a method of measuring features which do not damage the organism under scrutiny, and which gives an estimate of the organism's mass (Ludwig et al., 1975). We took 80 specimens of mountain mahogany at various sizes from the University of Wyoming's greenhouse and measured plant height and crown diameter, and then dried the specimens in a 60-degree drier and recorded the biomass. We found that mountain mahogany's crown diameter and plant height both correlate with biomass ($p<0.05$). This analysis will allow us to record an estimate of biomass repeatedly, which will give us an approximation of growth rate for the seed sources at each common garden.

Planned Analyses

Data for germination, survival and growth rate over two years will be analyzed with a repeated mixed measures model. We will determine whether geographic origin correlates with the plant's successful establishment by comparing the performance of seed sources at each site. Ultimately, this will detect whether local seed sources are more successful than non-local sources (McKay et al., 2005). Results will be analyzed each year to determine whether location, soil type and/or climate affect the germination and long-term growth and survival of mountain mahogany.

Expected Results

We expect to find evidence for local adaptation of mountain mahogany in the transplant plots. Local adaptation is apparent when local populations have higher germination, survival, and growth rates compared to non-local seed sources. This is characterized as a home-site advantage. We anticipate that elevation, latitude, and climatic differences between seed source populations will correlate with fitness measures at the common gardens. My hypothesis is that seeds derived from distant geographic or environmental regions will have lower fitness at transplant sites relative to seeds from local sources and similar environmental conditions (elevation, soils, climate).

Potential Future Studies

Greenhouse study

We plan to conduct a series of greenhouse studies to compare seed sources for differences in germination, survival and growth rate based on soil type and cold stratification treatments. A New Mexico study has shown a significant difference in cold stratification requirements for germination based on elevation of origin in mountain mahogany (Rosner et al., 2003). There are also differences in soil features across the range of mountain mahogany (Soil Survey Staff, 2013), and edaphic origin may also affect local adaptation (Yost et al., 2012).

Spatial analysis

Seed zone analyses often include spatial analysis to corroborate common garden results (Erickson et al., 2004; Johnson et al., 2010; Pickup et al., 2012). We plan to perform spatial analyses across the range of mountain mahogany to test whether fitness measures from the transplant study correlates with the ecoregion of origin. This will help direct the collection of mountain mahogany seed for use in reclamation.

Molecular markers

We have collected leaf tissue from across mountain mahogany's range (Figure 1). We hope to use this germplasm to sequence neutral molecular markers developed by Brian Heuval from University of Colorado Pueblo, and Dan Potter from the University of California Davis. These markers may indicate genetic groupings, which we could then use to predict local adaptation.

We have also collected seeds and corresponding leaf tissue from 20 individual plants at populations from each common garden location. We plan to run genetic marker analyses to measure the patterns of gene flow in each population. This will tell us whether there are any differences in the outcrossing rate across the range of mountain mahogany, and provide further evidence for creating seed zones.

Soil analysis

Soil samples were collected from each of the populations at transplant sites. These collections will be processed in the soil laboratory at the University of Wyoming to determine if there are any differences in soil texture, pH, organic matter, estimated nitrogen availability, soluble salts, and measures of soil biota. These analyses will describe environmental factors that may drive adaptation at each common garden site and assist with interpretation of greenhouse studies of plant-soil interactions.

Discussion of Significance

Mountain Mahogany has become a recommended reclamation plant because of its widespread distribution, wildlife habitat value, and ability to grow in nutrient poor and rocky conditions. However, little research has been accomplished to understand planting requirements and environmental tolerance of this species. By comparing the performance between populations of different origin we can provide evidence to support best practices for seed sourcing when using this species for reclamation. Comparisons between disturbed and undisturbed sites will also result in recommendations to improve survival of mountain mahogany plantings, and will assist future reclamation activities throughout the Rocky Mountain region. Ultimately, the data collected from this transplant study will ensure that future reclamation of mountain mahogany shrublands will establish sustainable populations suited for site conditions, resulting in long-term reclamation success.

Figures:

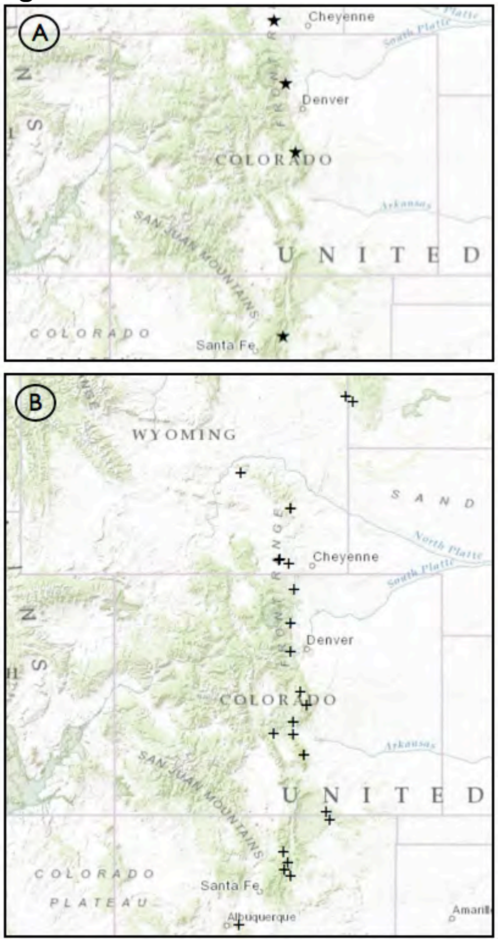

Figure 1: A) Map of common garden locations, B) seed source collections, and C) germplasm collections.

Figure 2: Line drawing of leaves, flower and fruit of *Cercocarpus montanus*.

(Janish, 1969)

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