Brush management and grassland conservation: an ecosystem services perspective

Adam T. Naito[1], Steven R. Archer[1], Philip Heilman[2], Katharine I. Predick[1]

[1]School of Natural Resources and the Environment, University of Arizona; [2]Southwest Watershed Research Center, USDA-ARS;

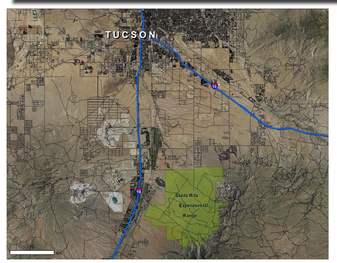
Introduction

- Woody encroachment into rangelands in the central and western United States has been ongoing for the last century. This encroachment has impacted numerous ecosystem services (ES), including losses of groundwater resources and available forage for cattle, as well as increased erosion potential.
- Expensive brush management (BM) operations (mechanical, chemical, pyric) are aimed at re-establishing these ES. However, evidence suggests that BM operations have limited effectiveness and are not economically feasible. However, like woody encroachment, BM also affects other ES.
- A comprehensive ES perspective on woody encroachment and BM is required to determine if, and to predict when, where and under what conditions, management interventions should be undertaken to meet diverse suites of conservation and sustainability goals.

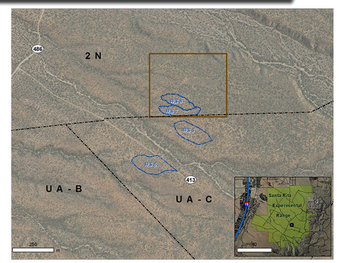
Goal and Objective

- Quantify trade-offs between woody plant encroachment and BM on the provision of key rangeland ES so that land managers can better prioritize the location and timing of management actions and objectively evaluate competing land use scenarios.
- Compare and contrast the provision of a portfolio of ES on intact, shrub-invaded watersheds with those on shrub-invaded watersheds that have received BM using spatially-explicit field-based data and simulation modelling.

Study Area



The study is being conducted on four instrumented watersheds (outlined in blue). The area within the brown polygon underwent BM in June 2016. Black dotted lines and black labels indicate individual grazing pastures.



The SRER, the world's oldest continually-operating ecological research facility, is located 45 km (28 mi) south of Tucson, AZ. SRER is owned by the State of Arizona is managed by the University of Arizona.

- Four watersheds on Santa Rita Experimental Range (SRER) 45 km south of Tucson, Arizona. Established in 1974 by USDA-ARS. Instrumented for runoff and sediment yield. Historical and current land use has been cattle grazing.
- Dominated by velvet mesquite (*Prosopis velutina*) in a matrix of lovegrass (*Eragrostis lehmanniana, Eragrostis curvula)*, cottontop (*Digitaria californica*), bristlegrass (*Setaria macrostachya*) and threeawn (*Aristida* spp.).

Methods

Two of the 120 mesquite individuals where ES are being tracked. Top individual is recovering from herbicide application, and bottom individual in control area.

- Two watersheds designated as controls, two received aerial application of herbicide (clopyralid + aminopyralid + triclopyr) in June 2016.
- The following were quantified before and after herbicide application under and away from up to 90 mesquite canopies for 3.5 years:
  - Aboveground herbaceous diversity and biomass.
  - Aboveground woody biomass
  - Coarse woody debris and litter
  - Soil carbon and nitrogen (0-20 cm)
  - Soil respiration, evapotranspiration, and net ecosystem exchange.
  - Runoff and sediment yield
  - Mesquite mortality and long-term (28+ months) foliar response to herbicide application.
  - Ground cover (woody, herbaceous, bare) and aboveground woody biomass changes via drones and ground-based structure-from-motion.
- The following were characterized after herbicide application for one year:
  - Seasonal variability in arthropod community composition via ant nest mapping and specimen collections from pitfall traps.
  - Characterization of seasonal variability in small mammal community composition and diet preferences using isotopic analyses of hair samples.
- Data derived from field-based measurements, flux towers and drones are being used to parameterize spatially-explicit soil biogeochemical (e.g. CENTURY) and hydrologic (e.g., AGWA, t-RIBS) models to predict long-term trends and patterns.

Undergraduate students currently employed as technicians on the project.

The study area, looking south towards the Santa Rita Mountains, January 2016

The ASU flux tower, May 2016

Aerial application of herbicides via helicopter, June 2016

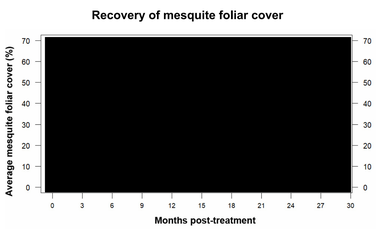
ASU flux tower and mesquite one week following application.

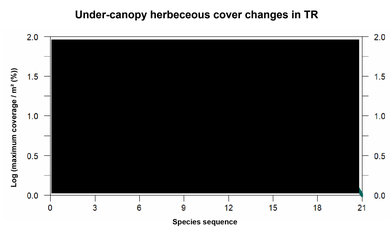
The study site approximately one month after treatment.

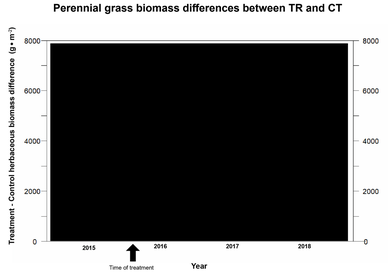
Red angus cattle at the study site.

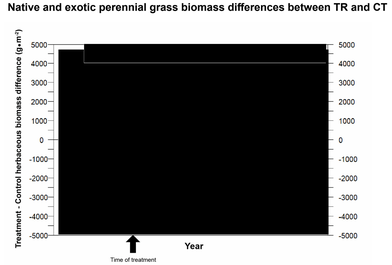
Results and Implications

- In terms of herbaceous composition and biomass, control (CT) and treatment (TR) areas very different. Intercanopy (IC) patches generally [redacted], while patches associated with mesquite canopies (UC) [redacted].
- The herbicide effectively defoliated mesquite, [redacted]
- Herbaceous richness [redacted]
- TR perennial bunchgrass biomass [redacted]
- Relative to CT, [redacted]
- This work serves to provide insights as to how a portfolio of ES may be impacted by BM under **realistic environmental conditions and financial and logistical constraints**, as multiple treatments are often not feasible.









Mesquite foliage recovery after herbicide application at (from top to bottom): 1 month, 3 months, 9 months, and 16 months following treatment.

Next steps and Impacts

- Continue field data collection for one additional year; longer with Long-Term Agroecosystem Research (LTAR) Network support. Assess economics of shrub encroachment and BM within a decision support framework.
- Short-term effects of BM on ANPP and soil C extended to longer time-scales and over contrasting climate scenarios using CENTURY.
- Hydrological modeling through AGWA and t-RIBS models will project hydrological impacts of BM under future environmental conditions and land use scenarios.
- Compare/contrast ET and NEE (flux towers) responses.
- Outside-of-Classroom Education: 34 undergraduates (24 women; 10 men) have provided nearly 3200 hours of field and lab support. Seven students have received UA Department, College, and University awards.
- Community outreach:
  - Website: https://cals.arizona.edu/research/archer/bmes/
  - Desert Landscape Conservation Cooperative case study on Actionable Science: https://bit.ly/2ALigpo
  - Mini-documentary: https://youtu.be/W6YO_dP-iKE
  - Presentations at:local/regional workshops, local and national conferences, and symposia organized by producer groups and NGOs.

B33E-2708