Brush management and ecosystem services:

a quantification of trade-offs on Western rangelands

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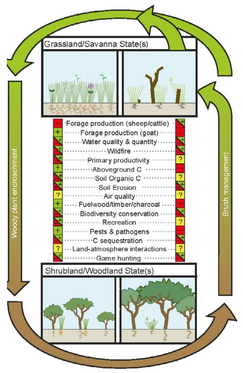
Introduction

- Sustainable range management requires maintenance of a desirable mix of grasses and shrubs.
- Unpalatable shrubs have proliferated in many rangelands in recent decades, necessitating expensive brush management (BM) historically aimed at re-establishing forage production.
- The preponderance of evidence suggests BM efforts are typically short-lived and not economically feasible from a forage production standpoint. However, shrub proliferation and BM also affect numerous other ecosystem services (ES).
- A broader ES perspective on shrub proliferation and BM may fundamentally change how we manage woody vegetation in rangelands, but we are poorly positioned to predict or objectively evaluate trade-offs or synergies in management scenarios that will occur.



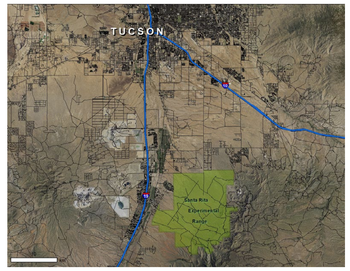
Goal

- Quantify trade-offs between woody plant encroachment and BM on the provision of key ES so that land managers can better prioritize the location and timing of management actions and objectively evaluate competing land use scenarios.

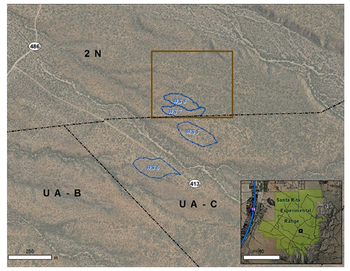
Objective

- Compare and contrast the provision of a portfolio of ES on intact shrub-invaded watersheds with that of watersheds where encroaching shrubs have been herbicided using spatially-explicit field-based data and simulation modelling.

Study Area



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.



The study area centers on four instrumented watersheds (outlined in blue) in a desert grassland ecosystem in the south-central portion of SRER. The area enclosed by the brown polygon underwent BM in June 2016. Black dotted lines and black labels indicate individual grazing pastures.

- Four watersheds on the Santa Rita Experimental Range (SRER) 45 km (28 mi) south of Tucson, Arizona.
  - Established in 1974 by USDA-ARS.
  - Instrumented for runoff and sediment yield.
- Dominated by velvet mesquite (*Prosopis velutina*), lovegrass (*Eragrostis lehmanniana, E. curvula*), Arizona cottontop (*Digitaria californica*), and threeawn (*Aristida* spp.).
- The primary historical and current land use has been cattle grazing.

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

The ASU eddy covariance tower, May 2016

UA student technicians on project: (L to R): A Branz, AC Grant, A Michaels, CE Pijanowski, MR Stahl

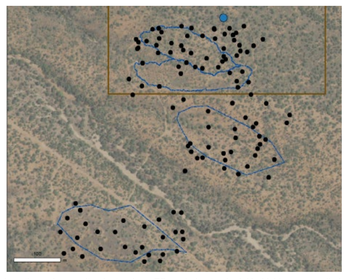
UA student technicians on the project: (L to R): B Slomka, K Wang, VR Friess, CJ Schwartz, EN Runnion

Aerial application of herbicides to the study site via helicopter, June 2016

The ASU flux tower and mesquite one week following herbicide application.

Methods

- Two watersheds designated as controls, two received aerial application of herbicide in June 2016.
- Arizona State EC tower occurs on one of the treated watersheds; ARS EC tower occurs in a nearby control area. Both towers equipped with identical instrumentation to measure ET and NEE.
- The following were quantified before and after herbicide application for:
  - Aboveground herbaceous diversity and net primary production
  - Aboveground woody net primary production and response to herbicide application
  - Coarse woody debris and litter
  - Soil carbon and nitrogen (0-20 cm)
  - Soil respiration, ET, and NEE
  - Runoff, erosion, and sediment yield
  - Number and configuration of rodent burrows
  - Ground cover (woody, herbaceous, bare) and aboveground woody biomass changes via UAVs and ground-based SfM.
- Data derived from field-based measurements, flux towers and UAVs will be used to parameterize spatially-explicit biogeochemical (e.g. CENTURY) and hydrologic (e.g., AGWA, t-RIBS) models to predict long-term trends and patterns.

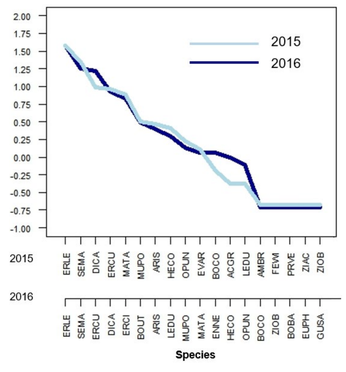


Locations of mesquite plants where ES are being tracked. Herbicide was applied to area inside brown polygon in June 2016.

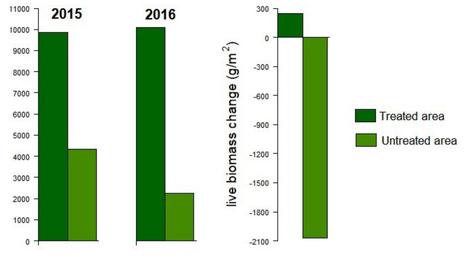
One of the 120 mesquite individuals where ES are being tracked. This individual is recovering from herbicide application.

Preliminary Results

Herbaceous diversity changes



Herbaceous biomass changes



Rank abundance diversity curves and herbacesous biomass (peak season) in 2015 (before) and 2016 (~3 mo. after) treatment.

Mesquite foliage recovery after herbicide application.

- At end of 2016 growing season, ~3 months after herbicide treatment of shrubs:
  - Herbicide effectively defoliated mesquite, but plants are quickly recovering. Mortality only ~5%.
  - Herbaceous production declined 44% between 2015 (pre-treatment) and 2016 on control site, but was maintained on the herbicided site.
  - Native and non-native perennial grasses have both responded comparably.
  - Herbaceous diversity not yet significantly altered, but intial trends suggest non-natives have potential to replace native perennials.

Impact

- Concurrent quantification of BM on broad portfolio of ES.
- Short-term effects of BM on ANPP and soil C extended to longer time-scales and over contrasting climate scenarios using CENTURY.
- AGWA and t-RIBS models will project hydrological impacts of BM under future environmental conditions and land use scenarios.
- Flux towers will quantify changes in ET and NEE and help parameterize and evaluate CENTURY, AGWA and t-RIBS.
- The economics of woody plant encroachment and BM will be assessed within a decision support framework.
- Outside-of-Classroom Education: 26 undergrads (18 female and 8 males representing Asian, Caucasian, Hispanic ethnicities; ranging from FR to SR) have assisted with field and lab work to date.
- Community outreach:
  - website: https://cals.arizona.edu/research/archer/brush-management_ecosystem-services/index.html
  - Presentations at:
    - local/regional workshops
    - symposia organized by producer groups and NGOs