Patterns of surface rock cover and implications for plant, water, and nutrient dynamics at long-term ecological research sites in Phoenix, AZ

Julea Shaw, Sharon J. Hall, and Jennifer Learned

School of Life Sciences, Arizona State University, PO Box 874501, Tempe AZ 85287-4501

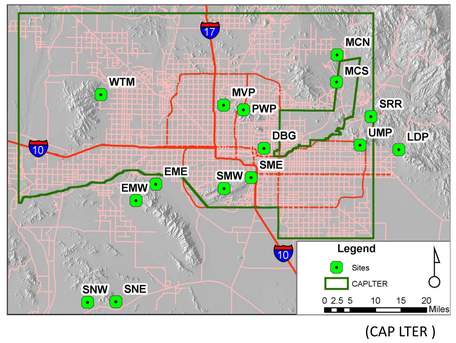
Background

- The main drivers of net primary productivity (NPP) in arid ecosystems are water and nutrient availability.
- Plant sensitivity to nitrogen, the primary limiting nutrient, varies depending on water availability.
- Factors that influence water availability would be expected to have an impact on NPP.
- While precipitation is the main factor in determining water available to plants, other more local factors such as surface rock cover may also have an impact.
- Previous studies have shown that surface rock cover influences both infiltration and evaporation of water in soils, but the direct relationship between surface rocks and aboveground NPP (ANPP) is unclear.
- In this study we aim to explore the relationship between surface rock cover, ANPP of winter annual plants, and soil nutrient availability.

Predictions

- Rock cover will be positively related to ANPP because higher rock cover will increase water availability to plants.
- Rock cover will have the most significant and positive effect on ANPP in nutrient enriched (fertilized) plots

Survey Sites



(CAP LTER)

We conducted rock cover surveys at fourteen CNdep sites within and surrounding the greater Phoenix area (left). Each site contains 20 m x 20m plots with four fertilization treatments: N, P, N+P, and Control.

Methods

Surface Rock Cover Surveys: We measured percent cover of rocks in eight 1m x 1m quadrats on plots at each site. Rocks were divided into four classes based on diameter: gravel (<7.5 cm), cobble (7.5-25 cm), stone (25-59 cm), and boulder (> 60 cm).

Analysis: We performed regression analyses to explore the relative importance of rock cover and winter precipitation on ANPP of winter annuals across all sites and years

Results

Figure 1

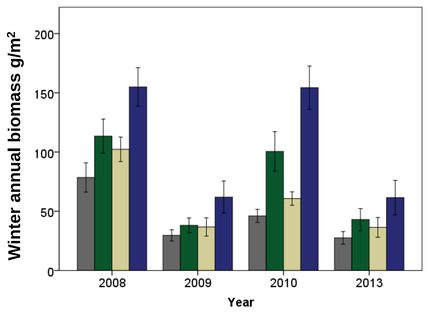
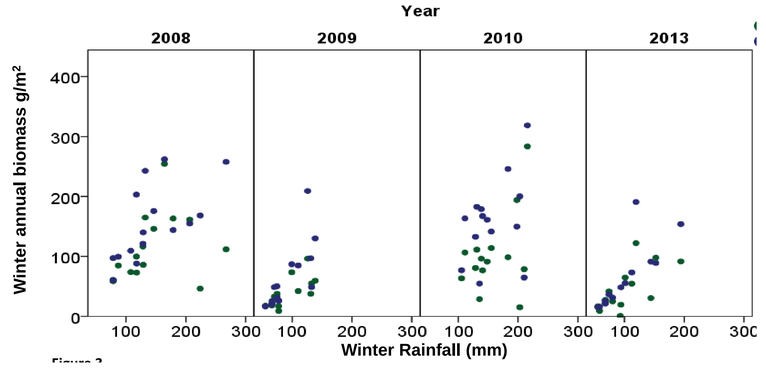
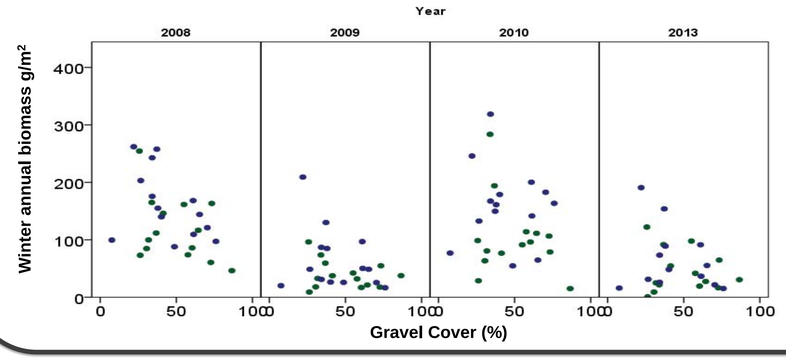


Figure 1: ANPP of winter annual plants is limited most strongly by nitrogen (N) and secondarily by phosphorous (P). Treatments: Control (grey), N (green), P (tan), N+P (blue).

ANPP of winter annuals is positively related to rainfall (Figure 2) but negatively related to surface gravel cover in most years (Figure 3). Multiple linear regression: Rainfall, $p < 0.01$; Gravel, $p < 0.01$





Conclusions

- Rainfall, soil nutrients, and surface rock cover together are strongly related to the growth of Sonoran Desert annual plants.
- Preliminary analysis showed that of the classes of rocks, gravel was the only one with a significant effect on biomass.
- Plant growth was positively related to rainfall as expected, but negatively related to gravel cover.
- Surface rock cover significantly influences ANPP in this arid system. Although rocks can reduce evaporation (thus increasing water availability), they may also reduce light availability or increase soil temperature, which may negatively effect plant germination and growth.

Next Steps

Manipulative experiment

- To better understand how rock cover influences the amount and duration of water in soil, we will perform a manipulative experiment.
- We will manipulate rock cover on 1 m x 1m plots and use soil moisture probes to measure water retention in soil after rain events.

Acknowledgements

We would like to thank all of the members of the Hall Lab for their input and unending support. Also a special thanks to Ellen Brooks, Bryson Olson, and all of the field volunteers who braved the summer heat to make this possible.

ASU Arizona State University

Central Arizona-Phoenix Long-Term Ecological Research CAP LTER