Draft 1

Questions?

Does RDM predict insect abundance or diversity?

Why – it is commonly used by land managers.

How – regression

Does productivity (RDM) change along the gradient?

Does shrub/open/RDM change along the gradient?

How to integrate hoppers? Guilds of insects?

Analyses:

CCA for insect species

Rationale

Foundation plants play a central role in structuring arid environments. Microclimate amelioration and other mechanisms can affect survival, growth, and reproduction of annuals plants. The positive effects of vegetation can propagate through other trophic levels, including both primary and secondary consumers. Complex direct and indirect effects.

Residual dry matter (rdm) is a common measure of productivity in drylands.  It is comprised of both direct and indirect drivers on plant composition and structure including resource availability, plant-plant interactions, and interactions with consumers.

Arthropods depend on plants, vertebrates depend on arthropods and shrubs. Plants depend on shrubs. In arid ecosystems, arthropods mediate resource flow and structure the surrounding community (Whitford, 2000). Further, ground dwelling arthropods including Coleoptera and Orthoptera are the major component of the diet of Gambelia sila, the federally listed lizard (Germano, 2007).

We used a rainfall gradient of arid grasslands in Southern California. At Panoche and other semi-arid dryland sites, blunt-nosed leopard lizards are secondary consumers on grasshoppers and other invertebrates. A survey of rdm under shrubs and in the open will facilitate an assessment of productivity associated with foundation plant species and estimate the strength of plant-plant interactions.  Importantly, burrow density will also be recorded at each sampling instance to infer secondary-consumer (and indirect) effects on community dynamics. The missing link, i.e. connector taxa in these systems, invertebrates will be also be sampled and identified using pan traps and pitfall traps.

In this study, we used structural equation modeling (SEM) to investigate the relative importance of causal factors influencing arthropod community composition. To describe complex, interrelated systems such as this one it is necessary to partition the direct and indirect effects. SEM can be used to model multivariate relations (Grace 2006, Bollen 1989) which increases our understanding of complex systems (Grace 2006, Shipley 2000). To answer these questions, we developed a theoretical model of hypothesized causal relationships among variables in this shrub-annual–arthropod system.

Questions

1) A survey of rdm under shrubs and in the open will facilitate an assessment of productivity associated with foundation plant species and estimate the strength of plant-plant interactions.

2) Importantly, burrow density will also be recorded at each sampling instance to infer secondary-consumer (and indirect) effects on community dynamics.

3) To disentangle the relation

4)

Evaluating hypotheses that partition direct and indirect effects requires an analytic framework that is designed to model multivariate relations between system components ([Grace, 2006](https://www.sciencedirect.com/science/article/pii/S0378112709003211" \l "bib25)). SEM is an extension of regression and path analysis that can be used to model multivariate relations and to evaluate multivariate hypotheses ([Bollen, 1989](https://www.sciencedirect.com/science/article/pii/S0378112709003211" \l "bib6)). The use of SEM has gained favor in recent years due to its potential to increase understanding of complex systems ([Shipley, 2000](https://www.sciencedirect.com/science/article/pii/S0378112709003211" \l "bib50), [Grace, 2006](https://www.sciencedirect.com/science/article/pii/S0378112709003211#bib25)). In turn, resulting information can be used to improve effectiveness of resource conservation efforts. In this study, we asked the following specific research questions: (1) Are arthropod abundance and family richness on C. fendleri positively related to protection of plants from large ungulate herbivores? (2) Does protection of C. fendleri from ungulates increase diversity of arthropod functional groups? (3) Are direct effects of protection more important in determining arthropod abundance and richness than indirect effects? (4) Is aerial stem length more important in affecting changes in arthropod assemblage than number of stems or number of flowering stems? ([Fig. 1](https://www.sciencedirect.com/science/article/pii/S0378112709003211" \l "fig1)).

Methods

Site description -> maybe a map?

Study species

Ephedra is…. Larrea is…

Field and lab methods

Between the dates of June 23rd and July 8th, 2019, I sampled 3 sites each within 3 desert regions. At each site, I chose 30 shrub open pairs. The shrub was Ephedra californica, at Mojave it was ephedra and larrea tridentata. Open sites were located at least 1.5 m away. At each microsite, a 0.5m by 0.5 m quadrat was placed on the northern aspect, the open sites were chosen by throwing the quadrat over my shoulder. Within each quadrat, I estimated cover, and measured the max vegetation height. Count number of burrows in a 1.5m radius around quadrat.

In each microsite record: Plant height and estimate cover: RDM, green veg, bare/small twiggy cover, dead branches and large wood, large rocks.

Shrub x, y, z. Species. Put RDM in paper bags, label.

8 ephedra/open pairs or 8 ephedra/larrea/open trios for mojave

Dig into ground, parallel to surface. These go in centre of 0.5m quadrat. Fill halfway with a 50% propylene gycol/water mix. Leave out for approximately 72 hours, top up with water as need. Pick up and collect remaining RDM from the right side of the pitfall. If totally unaccessible (i.e. there is shrub roots there) or if surface was disturbed place on left side. Left side only happened ~5 times. Sieve out inverts, place gycol mixture back in bottle. Glycol mixture was reused. Don’t count springtails or similarly tiny inverts because they didn’t all get caught by the sieve. Place in separate vials, add label and 95% ethanol.

RDM was dried in a blank oven at 85 celsius for 72 hours and then weighed using blank scale.

Insects were identified depending on the group. They were morphotyped.

Exclusions: Mutillids were not morphotyped because of strong sexual dimorphism. Alate ants were also excluded because I don’t even have keys to get to genus, let one morphotype them (total number - ~individuals).

Springtails and insects smaller were excluded due to mesh sizes. Larval stages (n = x) and hemipteran nymphs that could not definitively be associated with the adult form were excluded.

Analysis

To test for differences in arthropod communities associated with Ephedra californica, we fit generalized linear mixed models (glmmTMB). For abundance, one sample was excluded as an outlier (it had 1200 individuals and everything else is below 350). Microsite and RDM were included as predictors, and the study site nested within the region was included as a random effect.

Turnover – bray-curtis dissimilarity, then anova on NMDS axes

-Indicator species analysis for insects

- Abundance and diversity depends on rdm/shrub?

-RDA or CCA for veg + sites

Results

Arthropod community responses: A total of ~6300 arthropods were collected. Herbivore, pred etc. Ants were the most abundant group.

* Arthropod abundance and morphospecies richness greater under shrubs. No influence of RDM.
* RDM higher under shrubs.
* No arthropod response to RDM at all.
* RDA & CCA show community are different.
* Also betadispersion tests show same results.

Discussion

Camel crickets important to antelope squirrel diet in winter and spring (Harris, 2019).

**Figures and Tables**

Map of 3 study sites

Table of counts of morpho-species

Boxplots of RDM, abun, H and evenness for each region, split by microsite

RDM linear models of RDM & abun….