Bottom-up vs. top-down regulation of desert annual plants in an urban arid ecosystem

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Urbanization alters factors related to plant growth

The net primary production (NPP) and community composition of winter desert annual plants are influenced by **bottom-up factors such as soil inorganic nitrogen (iN) and water availability**, as well as **top-down factors such as herbivore populations**. Urbanization can change the availability of bottom-up resources [1,2], and alter the abundance and species richness of herbivores [3, 4, 5]

The relative importance of these factors for herbaceous winter annual plants across the Phoenix metropolitan area – key resources for Sonoran Desert consumers – is unknown.

We asked: How do soil iN pools, water availability, and herbivores influence the NPP and community composition of annual herbaceous plants in desert urban parks of Phoenix, AZ compared to the surrounding desert?

Site Description:

• 10 Central Arizona-Phoenix Long-Term Ecological Research sites: **5 urban sites** in Phoenix remnant desert parks and **5 non-urban sites** in the Sonoran Desert (Fig. 1).

• Average winter precipitation 2005-11: 90/133 mm (urban/non-urban) and winter precipitation in study year (2010-2011): 82/113 mm (urban/non-urban).

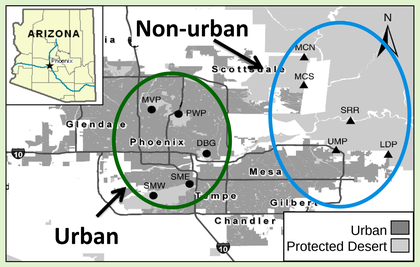

Fig. 1: Urban and non-urban study sites in Phoenix and the surrounding Sonoran Desert

Methods:

1. Soil iN (measured with Plant Root Simulator probes) and precipitation (mm) were collected from all sites during winter/spring 2010-11.

2. **3 herbivore exclosure plots and 3 control plots** (Fig. 2) were installed at each site in Dec 2010 to exclude small mammals and birds.

3. Aboveground plant biomass and community composition were collected in Apr 2011. Biomass data was ln-transformed for all analyses.

Fig. 2

Exclosure plots exclude herbivores

Control plots allow herbivore access

Regulating factors of primary production in Phoenix, AZ

How do bottom-up factors influence NPP?

Predictions: We expect herbaceous production to be positively related to precipitation and soil iN - resources that are necessary for annual plant growth.

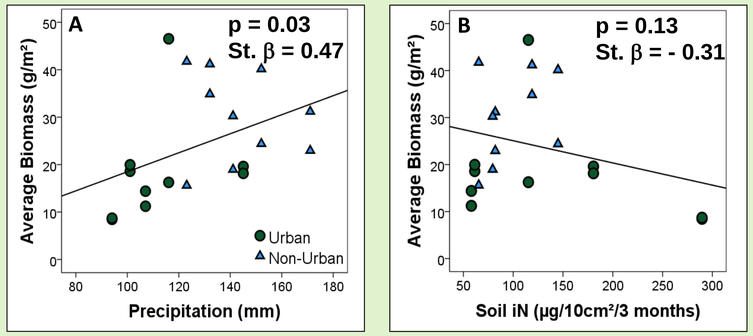

Fig. 3: A) Multiple regression analysis for annual plant growth with precipitation and B) soil iN. Standardized beta values correspond to the variable on the x-axis.

Results: Annual herbaceous biomass was significantly related to precipitation (Fig. 3A), but was not significantly related to soil iN across the Phoenix area (Fig. 3B).

How do top-down factors influence NPP?

Predictions: Herbivores are expected to be more abundant in cities[2], thus, herbivores will consume (reduce) more biomass at urban sites than non-urban sites.

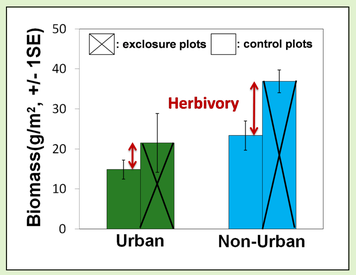

Fig. 4: Average biomass (g/m²; +/- 1SE) from control plots and exclosure plots in urban and non-urban sites. The influence of herbivory and site location were tested with ANOVA analyses.

Results: Plant growth is naturally greater at the wetter, non-urban sites (location main effect, **p<.05**; Fig. 4), and herbivory led to reduced biomass at all sites exclosure vs. control main effect, **p=0.05**). However, herbivory was not significantly different between site location (location*exclosure interaction, **p=0.52**).

Which factors are the most important for plant growth?

Precipitation

Herbivory

Soil iN?

Precipitation was the most important predictor of annual production, followed by herbivory (one-way ANCOVA: **p=0.02, p=0.04**, respectively). Soil iN was not significantly related to plant growth (**p=0.10**).

Regulating factors of annual plant communities in Phoenix, AZ

How does urbanization impact plant communities?

Predictions: We expect greater plant diversity at the non-urban sites than the urban sites, along with greater diversity within the exclosure plots compared to the control plots due to consumption by herbivores.

Examples of species common to urban and non-urban sites (17 total):

P. recurvata

S. arabicus

E. cicutarium

Species unique to non-urban sites (5 additional species):

Choristia

L. parisfloris

E. texanum

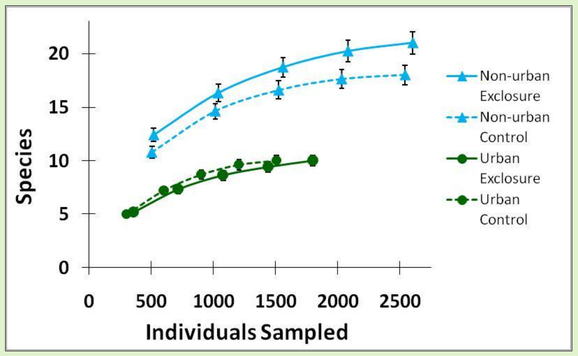

Fig. 5: Individual-based rarefaction curve (95% confidence intervals) for annual plant species from urban and non-urban control and exclosure plots.

Results: Species diversity was significantly greater at the non-urban than urban sites (ANOVA, **p<0.05**), but not significantly different between exclosure and control plots (two-way ANOVA, **p>0.05**). The individual-based rarefaction curve shows that herbivores decrease diversity at non-urban sites (Fig. 5).

Conclusions and Next Steps

- Precipitation was the most important predictor of annual biomass across Phoenix which led to greater primary production outside of the city.
- There were significant differences in annual plant diversity at the non-urban sites where there was the most primary production. Herbivores are less specific in their consumption of annual plant species when plant growth is limited.
- This study will continue in the spring 2012. We expect to see gradual changes in community composition as our plots alter annual plant growth and distribution over multiple seasons.

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