Shrubs alter patterns of inorganic nitrogen availability in native desert parks across metropolitan Phoenix

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Background

- Urban activities like fossil fuel burning have increased atmospheric nitrogen (Vitousek 1997).
- Net primary production in arid ecosystems is limited by nutrient and water availability.
- Nutrient and water availability in deserts is higher under shrubs (Schlesinger 1997).

Research Questions

Does proximity to Phoenix affect soil inorganic nitrogen availability to plants?

H1: Soil nitrogen availability is higher in desert parks within the urban core due to high nitrogen deposition from anthropogenic sources.

How does inorganic nitrogen availability vary with precipitation?

H2: Inorganic plant-available nitrogen increases with precipitation due to higher wet deposition.

Do shrubs concentrate nitrogen differently under different precipitation and deposition conditions?

H3: Shrubs concentrate plant-available inorganic nitrogen more in areas with higher precipitation due to increased breakdown of organic matter.

Methods & Sites

- We sampled 15 Sonoran Desert preserves: 5 east of the city, 5 west of the city, and 5 in the Phoenix urban core.
- Total plant-available nitrogen (nitrate and ammonium) was measured with Plant Root Simulator (PRS) probes in the soil at depths of 0-5 cm.
- Probes were placed between or under the dominant Sonoran Desert shrub *Larrea tridentata* (creosote bush) and were deployed for 68-71 days.
- Measurements were taken in the summer each year from 2009-2015.
- We created gamma-distributed generalized linear mixed effects models of nitrogen availability and averaged models with AIC weight > 0.01.
  - Fixed effects: total precipitation while buried, location under or between shrubs, region relative to Phoenix
  - Random effects: site, within site replicates, year

Figure 1. Site at South Mountain Preserve (left) and a PRS probe (right).

Results

Result 1: Total plant-available nitrogen in desert parks in the urban core was higher than in desert parks in the West Valley, but was not significantly different from the East Valley.

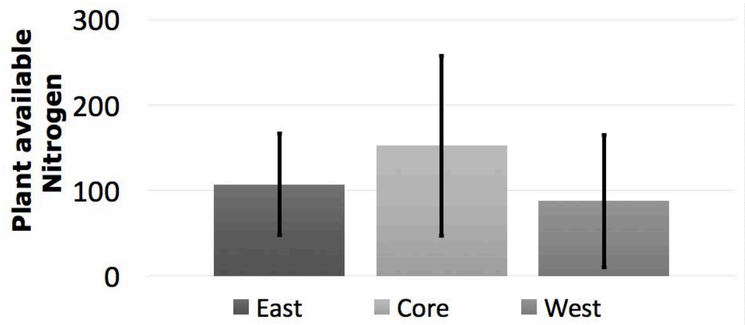

Figure 2. Total plant-available nitrogen in mg/cm²/burial length by region, averaged for all sites, years and positions. Error bars show standard deviation.

Result 2: Plant-available nitrogen increased with precipitation both between and under shrubs. However, the effect of precipitation was smaller in the East Valley. East Valley measurements show a decline in nitrogen with precipitation above ~80 mm.

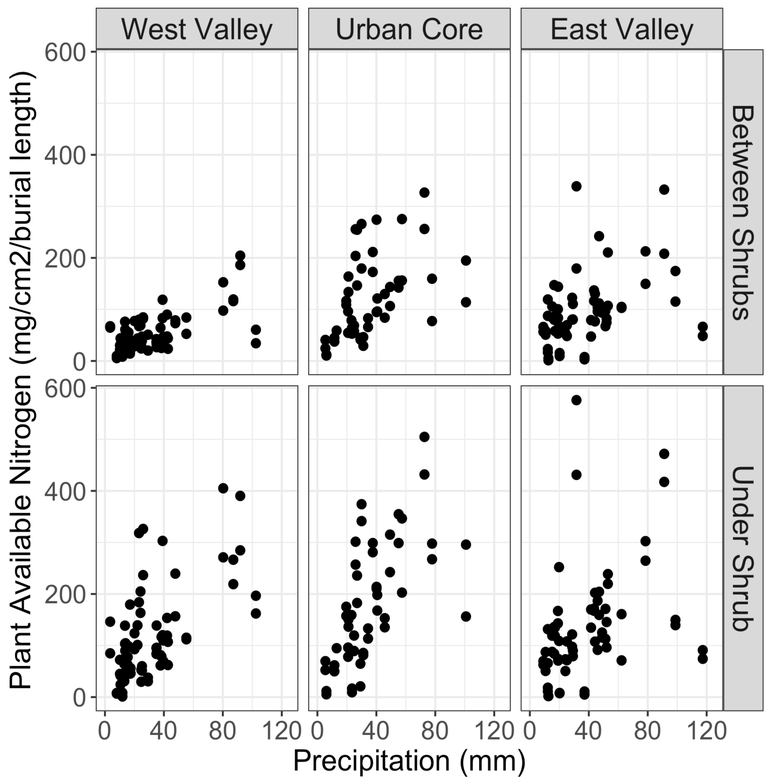

Figure 3. Precipitation and total plant available nitrogen between or under shrubs for all regions and years.

Result 3: Shrubs concentrated nitrogen more in the West Valley than in other regions. In all regions, nitrogen was higher under than between shrubs. There was no interaction between precipitation and shrub effects.

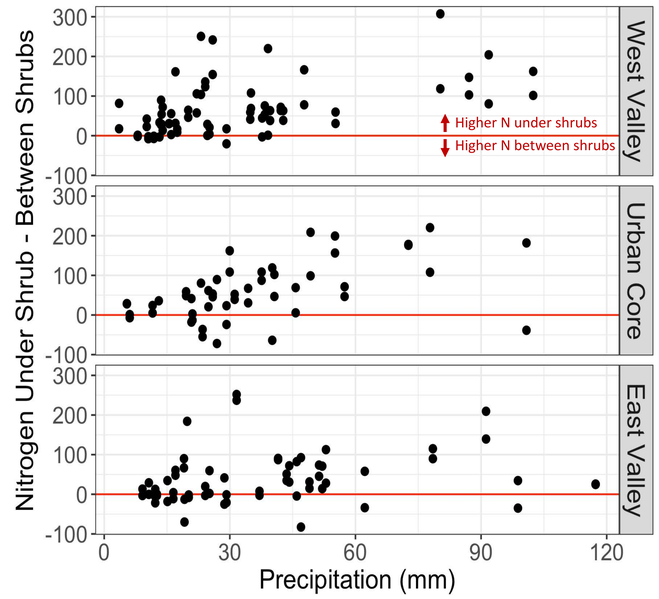

Figure 4. The difference between plant available nitrogen in mg/cm²/ burial length between and under shrubs over a precipitation gradient. The red line represents plant available nitrogen between and under shrubs being exactly equal.

Mixed Model Results

Table 1. Generalized linear mixed model coefficients. Predictors with * are significant at the 0.005 level.

Predictor	Coefficient	Std. Error	Relative Importance
East Valley	0.2	0.2	1
*West Valley	-0.7	0.2	1
*Precipitation	0.015	0.002	1
*Location Under Shrub	0.3	0.1	1
Under Shrub: East	-0.1	0.1	1
*Under Shrub: West	0.4	0.1	1
West: Precipitation	0.000	0.003	1
*East: Precipitation	-0.012	0.003	1
Under Shrub: Precipitation	0.000	0.002	0.33

Conclusions

- Precipitation, urban influences, and shrubs alter plant-available nitrogen in desert soils.
- Interactions with precipitation and region indicate that the effects of shrubs as islands of fertility are not constant, and changes in climatic conditions and nitrogen deposition may alter the relationship between shrubs and soil nutrients.

References

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Vitousek, P. M., Mooney, H .A, Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science*, *277*(5325), 494–499. https://doi.org/10.1126/science.277.5325.494

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