The interaction of soil surface gravel content and nitrogen deposition on the seedbank of invasive grasses in the northwest Sonoran Desert

Michael D. Bell[1*] and Edith B. Allen[1,2]

[1]Department of Botany and Plant Sciences, [2]Center for Conservation Biology, University of California, Riverside, California 92521

***Contact email: michael.bell@email.ucr.edu**

Introduction

The exotic grasses *Schismus arabicus* and *S. barbatus* (*Schismus*) are winter annual invasive species to arid and semi-arid regions that have been shown to increase in cover under nitrogen addition experiments. *Schismus* can produce enough biomass to carry fire in arid regions when subjected to greater than 5 kg/ha/yr of anthropogenic nitrogen deposition during an average rain year. Schismus cover decreases as percent cover of surface gravel increases. The objectives of this study were to examine the seedbank present in the top 5cm of soil in plots with a variable amount of rock cover at 8 sites spanning a nitrogen deposition gradient in Joshua Tree National Park to determine if the absence of seeds is limiting the spread of the grass in these areas, or if seeds are present in the soil and germination is limited by soil characteristics.

Background Information

- The invasion of exotic species into the California deserts has been rapid in the past 10-20 years.
- Excess nitrogen is being added to the atmosphere through vehicular exhaust and agriculture within the Greater Los Angeles Air Basin. The concentrated polluted air is transported by winds through the Banning Pass and is deposited within the boundaries of Joshua Tree National Park.
- Previous experiments have shown that nitrogen additions to the soil increase the cover of the invasive grass species *Schismus barbatus* and *S. arabicus*.
- Elevated soil N increases exotic grass cover to the detriment of associated native forbs and can out compete rare species that are generally uncommon in the community. Determining sites that are at highest risk of invasion will allow managers to prioritize their conservation efforts.
- As soil surface gravel content increases, the presence of Schismus cover decreases, but cover of native vegetation is not affected. The site-to-site variation in productivity of exotics may be controlled by local differences in soil type as well as N deposition and preciptation, so our ability to predict where invasives are abundant is limited by knowledge of soil type and texture.

References:

Allen, E.B., L.E. Rao, R.J. Steers, A. Bytnerowitcz, and M.E. Fenn. 2009. Impacts of atmospheric nitrogen deposition on vegetation and soils in Joshua Tree National Park. *In* Mojave Desert Science Symposium. University of Nevada Press, Tucson.

Brooks, M. L. 2003. Effects of increased soil nitrogen on the dominance of alien annual plants in the Mojave Desert. Journal of Applied Ecology 40:344-353

Rao, L.E., E.B. Allen, and T. Meixner, *Risk-based determination of critical nitrogen deposition loads for fire spread in southern California deserts. Ecological Applications, 2010. 20(5): p. 1320-1335.*

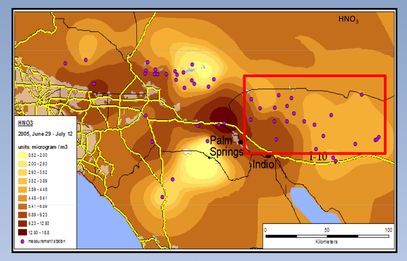
Rao, L. and E.B. Allen, *Combined effects of precipitation and nitrogen deposition on native and invasive winter annual production in California deserts. Oecologia, 2010. 162(4): p. 1035-1046.*

Methods

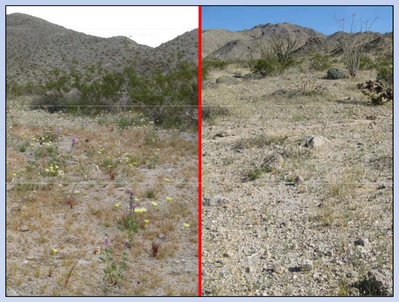
- At each site, four 5cm deep soil samples were taken and composited from the north and south side of 4 different *Larrea tridentata* shrubs.
- Two of the shrubs from each site were growing in areas of high surface gravel and two of them in low surface gravel.
- The soil was then watered continuously under greenhouse conditions and seedlings were identified, counted and removed as they germinated.
- Vegetation percent cover data was collected the following spring to compare greenhouse germination to field germination.

Collecting soil from the drip line of a *Larrea tridentata* shrub.

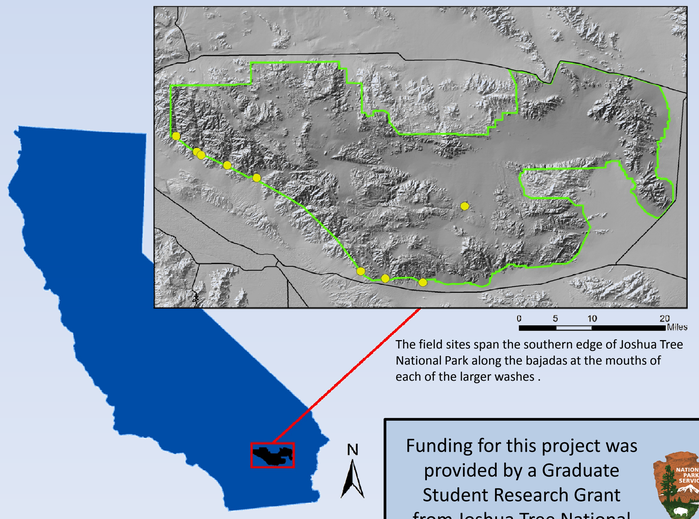
Schismus growing in the interspaces of *Larrea tridentata* shrubland



Measured southern California N deposition gradient (2005) with study area outlined.



These two sites are located 200 meters apart at Thermal Canyon. *Schismus* grows readily on the sandier site on the left compared to site on the right with more surface gravel.



The field sites span the southern edge of Joshua Tree National Park along the bajadas at the mouths of each of the larger washes .

Funding for this project was provided by a Graduate Student Research Grant from Joshua Tree National Park

Results

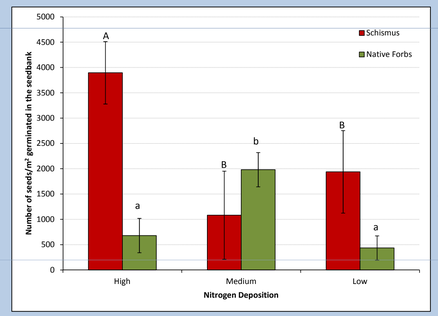


Figure 1: The number of *Schismus* seeds in the seedbank peaked in areas with nitrogen deposition above the critical load of 5 kg h^{-1} yr^{-1}. Seeds from native forbs peaked in areas below the critical load, but this relationship was driven by presence of a large number of *Crassula connata* seedlings.

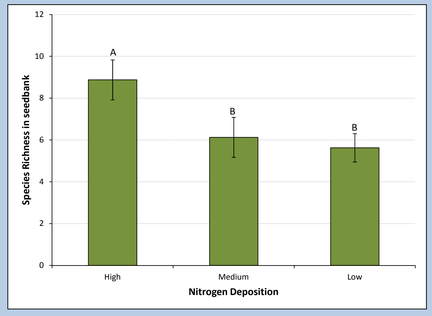


Figure 2: The richness of native species that germinated out of the collected seedbank in sites located in areas with nitrogen deposition above the critical load of 5 kg h^{-1} yr^{-1} was higher than that the richness in sites outside of the high deposition zone.

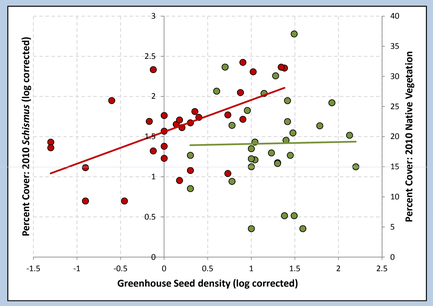


Figure 3: The amount of *Schismus* seed present in the seedbank is positively correlated with the amount of *Schismus* that germinated in the field the following spring (R^2 = .3338). The amount of native seeds found in the seed bank is not correlated to the cover of native vegetation measured in the field (R^2 = .0003).

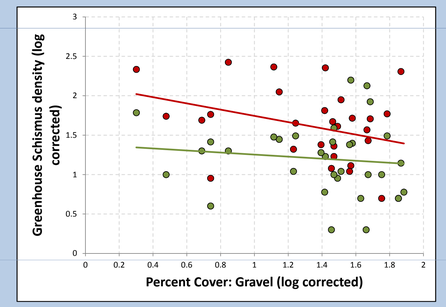


Figure 4: As surface gravel content increases across the landscape the number of *Schismus* seeds present in the seed bank is slightly reduced (R^2 = .1106) while the number of seeds germinated from the native seedbank does not respond (R^2 = .0138)

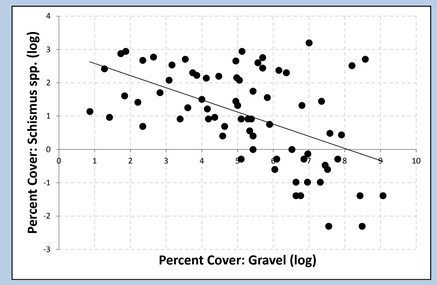


Figure 5: As surface gravel content increases across the landscape the percent cover of *Schismus* measured in the field declines (R^2 = .2716).

Discussion

- 39 plant species germinated across all of the plots with an average richness of 6.5 species per plot. The number of native forb seeds in high deposition sites was low, but richness remained high which may be related to the presence of increased nitrogen in the soil.
- The increase of *Schismus* seeds in high deposition sites (Figure 1) may be attributed to increased soil nutrient availability.
- There was a positive correlation between the number of *Schismus* seeds germinated from the seedbank and subsequent field cover of *Schismus* the following year (Figure 3). This indicates a high germination rate of *Schismus* seeds from year to year, and the propensity of the seeds to stay near the mother plant.
- There was no correlation between the number of native species germinating from the seedbank and the cover of native species measured in the field the following spring (Figure 3). This may be influenced by seed dormancy and the need for specific germination requirements of many native seeds.
- The reduction of *Schismus* seeds in the seed bank with increasing surface gravel content (Figure 4) is minor, but may be related to the reduced fitness of *Schismus* plants growing on these soils (Figure 5). Native forbs do not appear to respond to the increase in surface gravel, probably due to a change in species composition as soil characteristics change.
- These results show that changes in soil characteristics and nitrogen inputs into the soil can alter the ability of *Schismus* seeds to germinate in the desert ecosystem. The diversity of native forb seed present in the seedbank allows for different species to germinate depending on the conditions present.