Chronic drought severely alters plant species composition in arid grasslands

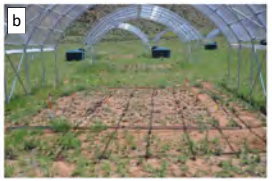
Lauren E. Baur (1), Scott L. Collins (1), Alan K. Knapp (2) and Melinda D. Smith (2)
(1) Department of Biology, University of New Mexico, Albuquerque, NM (2) Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO

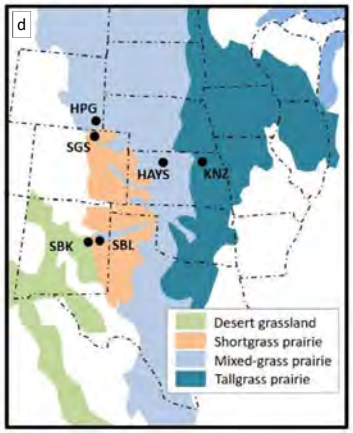
Question and Methods

How does mean annual precipitation relate to severity of drought effects?

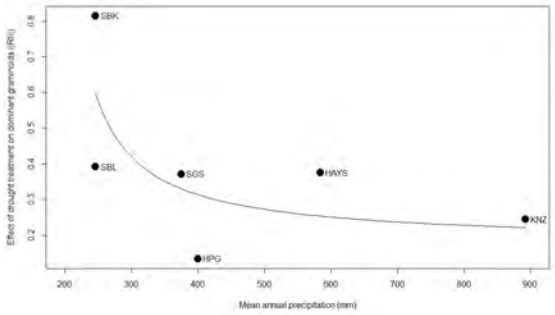
EDGE (Extreme Drought in Grasslands Experiment) used identical infrastructure to impose rainfall reductions at six sites spanning desert grassland, shortgrass steppe, mixed grass prairie, and tallgrass prairie.

We imposed chronic drought of 66% rainfall reduction in the growing season (June-October) for four years.

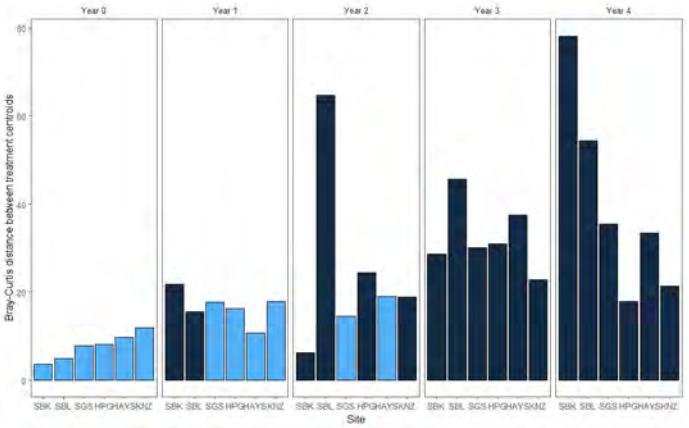




a) Sevilleta EDGE site in blue grama grassland (SBL)
b) A drought plot at SBL showing reduced cover of dominant grasses
c) Species composition quadrat in a control plot at the Sevilleta black grama site (SBK)
d) Locations of the six EDGE sites



Above: Nonlinear regression showing negative relationship between MAP and drought effect, largely driven by desert grassland sites (SBK and SBL)



Above: Bray-Curtis distance between treatment centroids for each site in each year of treatment. Light blue bars indicate that species composition did not differ significantly between treatments (P>0.05) according to PERMANOVA. Dark blue indicates P<=0.05.

Results and Conclusions

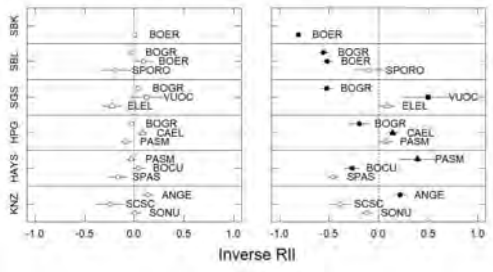
We found a nonlinear, negative relationship between the mean annual precipitation of the sites and the magnitude of drought effects on the dominant plant species. This pattern was largely driven by the two driest sites, located at the Sevilleta Long Term Ecological Research site (SEV) in New Mexico.

Plant species composition between chronic drought and control treatments diverged most rapidly at the SEV sites, and compositional differences were largest at the SEV sites in the last year of treatment.

At the SEV sites, chronic drought caused an extreme drop in abundance of the dominant C4 grass species, followed by temporary booms in annual forbs.

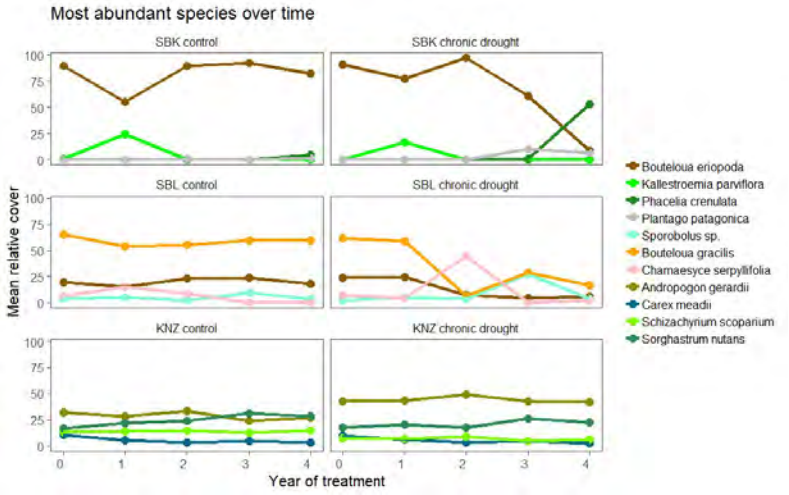
Other sites showed similar composition changes (decreases in C4 dominants and increases in C3 subdominants or annuals in the drought treatment), but with smaller magnitudes.

Our results indicate that arid desert grasslands may be particularly vulnerable to extreme drought under future climate change.



Above: Size of drought effect (expressed as inverse of relative interaction intensity) on dominant species at all sites in year 0 (left) and year 4 (right). Filled symbols indicate difference in cover between treatments was significant (P<=0.05). Circles represent C4 perennials, squares represent C3 annuals, and triangles represent C3 perennials.

Below: Most abundant species over time at desert grassland sites (SBK and SBL) contrasted with tallgrass prairie site (KNZ)



Acknowledgements: Funding from the National Science Foundation. Thanks to the staff of the Sevilleta National Wildlife Refuge, the Sevilleta LTER field crew and other techs and grad students who collected these data. Additional thanks to David Baur, Nathan Lemoine, Jenn Rudgers and Kate Wilkins.