Functional trait diversity in prairie plant species

Taran Lichtenberger[1*], Evelyn Williams[2], Andrea Kramer[1,2]

[1]Northwestern University, Evanston, IL, 60201, [2]Chicago Botanic Garden, Glencoe, IL, 60022

Introduction

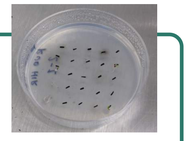
- Prairie Restoration: In the United States, more than 99% of the native tallgrass prairie ecosystem has been destroyed[1] leading to loss of important ecosystem services like water filtration, carbon sequestration, and sustaining wildlife[2].
- Restorations Fail: Restored prairies often fall short of remnant prairies in supporting species diversity and delivering ecosystem services. The diversity of functional traits expressed by species is important for restoring ecosystem services[3].
- Functional Traits: Ecological research on functional traits and ecosystem services often uses a single trait value for each species[4], despite the fact that values for functional traits can vary widely within a species[5]. Restoration planners would benefit from having data on the magnitude of functional trait differences between as well as within species, and the influence of these differences on the delivery of ecosystem services.

Hypotheses

1. Traits will vary significantly among populations within a species.
2. Functional trait variation within-species will be as great as between-species.

Methods

Seeds for four species and at least two broadly distributed populations (Fig. 1 of map) obtained from the Dixon Prairie Grass Seed Bank and germinated on agar plates.



Germinated seeds planted in cone-tainers in growth chamber simulating daylight and day/night temperatures of early summer in a Midwestern prairie.

After 35 days of growth, plants harvested, cleaned, dried and weighed. Seven functional trait measures taken.

Conducted nested analysis of variance to test for variance between- and within-species and t-test on pairwise differences in trait means between population and species.

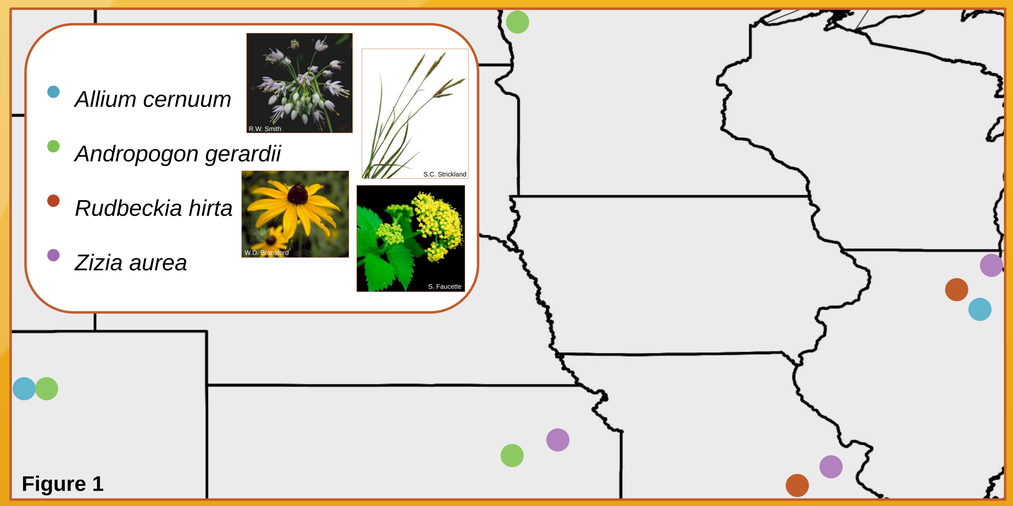


Figure 1

Results

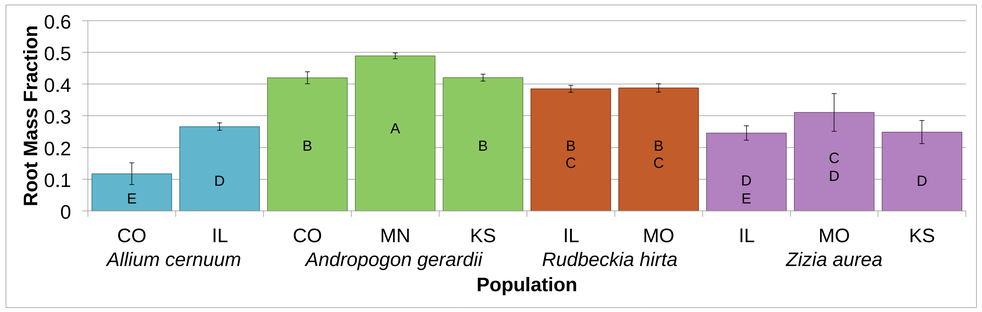


Figure 2 Variation in root mass fraction within and among study species. The root mass fraction for *Allium cernuum* populations and *Andropogon gerardii* populations was significantly different from one another and there were significant differences for all four species. Bars not labeled by the same letter are significantly different.

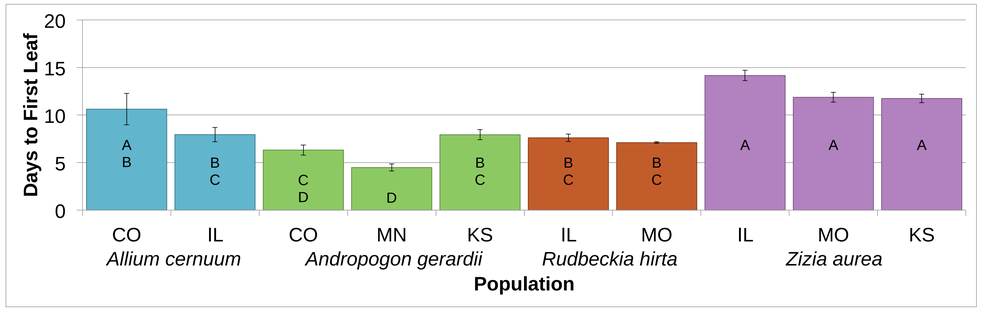


Figure 3 Variation in days to first leaf within and among study species. There were significant differences for the *Andropogon gerardii* between KS and MO populations and differences between all four species. Bars not labeled by the same letter are significantly different.

Table 1 Trait differences. All seven traits measured were significant between-species. Six of the seven traits measured were significant between populations nested in species.

Trait	Species	Population (Species)
Days to First Leaf	<0.0001*	<0.0001*
Maximum Vegetative Height	<0.0001*	<0.0001*
Root Length	<0.0001*	NS
Log of Specific Root Length (root length/root mass)	<0.0001*	<0.0001*
Root Mass Fraction (root mass/plant mass)	<0.0001*	<0.0001*
Leaf Dry Matter Content (dry leaf mass/fresh leaf mass)	<0.0001*	<0.0001*
Specific Leaf Area (leaf area/dry leaf mass)	<0.0001*	0.0205*

Discussion

Difference at Population Level: Differences in functional trait values were found between populations, although a majority of the variation was found across species (Table 1). The significant population level difference means that a single trait value does not represent the full variability for each species.

Traits and the Ecosystem: Variation in traits reflects differences in function. Additionally, the traits result in changes in ecosystem services. Above-ground traits like leaf dry matter content can change levels of carbon assimilation[4] and below-ground traits like root length and specific root length relate to soil resource capture[6]. Not every individual or species has the same functional trait value, which depends on where the seed came from, which affects ecosystem functions and diversity in a restoration.

Use in Restoration: Practitioners shouldn't assume that mixing populations of the same species will result in identical outcomes. This variability was observed in other studies and likely has an effect on restoration outcomes[7]. For example, seeds used in a restoration from geographically distant sources results in highly variable traits that may not necessarily be suited to the new site. Planners should be cautious when using a single trait value for one species, as population choice impacts the success of a restoration. Therefore, understanding functional traits makes for a more successful restoration.

Conclusion: Traits do very significantly among populations within a species, however, populations of the same species are still more similar to each other than to another species.

Further Questions

Future studies should include more species and expand upon the functional traits measured.

Literature Cited

1. Sampson, F. & Knopf, **36**F. (1994) Prairie conservation in North America. *BioScience,* **44,** 418-421.
2. 2. Naeem, S., Thompson, L. J., Lawler, S. P., Lawton, J. H. & Woodfin, R. M. (1994) Declining biodiversity can alter the performance of ecosystems. *Nature,***8,** 734-737.
3. Cadotte, M.; Carscadden, K.; Mirotchnick, N. (2011) Beyond species: functional diversity and the maintenance of ecological processes and services. *Journal of Applied Ecology*. **48**, 1079-1087
4. Albert, C.; Thuiller, W.; Yoccoz, N.; Soudant, A.; Boucher, F.; Saccone, P.; Lavorel, S. (2010) Intraspecific functional variability: extent, structure and sources of variation. *Journal of Ecology*. **98**, 604-613.
5. Scheepens, J.; Frei, E.; Stocklin, J. (2010) Genotypic and environmental variation in specific leaf area in a widespread Alpine plant after transplantation to different altitudes. *Population Ecology*. **164**, 141-150.
6. Hajek et al. (2013) Intraspecific variation in root and leaf traits and leaf-root trait linkages in eight aspen demes (*Populus tremula* and *P. tremuloides*). *Frontiers in Plant Science*, **4**, 1-11.
7. Kettenring, K.; Mercer, K.; Adams, C.; Hines, J. (2014) Application of genetic diversity- ecosystem function research to ecological restoration. *Journal of Applied Ecology*. **51**, 339-348.

Contact Information: *taranlichtenberger2018@u.northwestern.edu

Acknowledgments

Many thanks to the Chicago Botanic Garden and the Undergraduate Research Grant Program which is administered by Northwestern University's Office of the Provost for assisting in funding this research.

CHICAGO BOTANIC GARDEN

NORTHWESTERN UNIVERSITY