Functional Diversity and Benchmarks

While each plant functions differently in an ecosystem context, the degrees of dissimilarity which exist between all species are unequal allowing them to clump together into groups. This observation has given rise to the notion of *Plant Functional Types*, shared attributes which unite similar species, and which bind how they affect ecosystems. Oftentimes, form follows function, and functions are hence referred to as forms. For example, Trees provide large amounts of shade, which in combination with their transpiration lower the temperature of areas. Plant functional types are quite often the easiest form of vegetation data to measure, and accordingly great amounts of work have been conducted on how they affect ecosystem function.

In Western Colorado, five major forms of plant functional types are often used to evaluate range conditions. These forms are: Trees, Shrubs, Grasses, and Forbs (or herbs), and each has been linked to affecting rangelands in multiple ways. Accordingly, in nearly all instances a mix of each of these groups, less trees, is best to maintain ecosystem services on BLM Land. In our area which features massive extents of Pinon-Juniper Woodland, trees when present, are included in this mix on ecological sites which they are more capable of surviving on over long periods relative to shrubs.

Semi-arid lands which are utilized as rangelands across the world are experiencing several common issues relating to shifts in the composition of their plant functional types (Archer & Predick (2014), Eldridge et al. (2016), Maestre et al. (2016), Diaz et al. (2007)) . Namely, decreases in grasses whilst increases in woody species are occurring. In certain areas, the increases - or encroachment of - woody species may be split into encroachment of trees, and the transition to a shrub state in ecological sites which do not support trees. In nearly all lands utilized as rangelands around the world the cover of and species richness of perennial forbs decreases, while the cover of annual forbs increases (Diaz et al. (2007)).

The current increases in shrub cover relative to the cover of the herbaceous strata, grasses and forbs, are problematic for a variety of reasons. The increase in Trees at mixed grass-shrublands sites may decrease water available to grasses and shrubs but not non-native annual grasses (McIver et al. (2022)), as cattle depend on grasses and wildlife shrubs these decrease the ability of our lands to support either. Increases in shrubs at the expense of perennial grasses and forbs may increase the severity of site level drought (Wilson et al. (2018)), further shrubs and trees may foster higher severity fires (CITE). Increases in shrubs decrease soil stability, allowing increased erosion, increasing DUST ON SNOW, and is an irritant to human breathing (Munson et al. (2011)). Decreases in perennial grass may reduce competing non-native annuals from overtaking sites Sheley & James (2010), Corbin & D'Antonio (2004), although a diversity of species may be best (Belnap & Sherrod (2008)). A decreases in forbs adversely affect wildlife feeding both directly and indirectly, and by decreasing the quality of habitats, the lack of perennial forbs are widely evident for species such as the Gunnison Sage-Grouse (Pennington et al. (2016)). These issues we are currently facing may be compounded in the future by problems which are only begin to become apparent.

While the major functional groups are capable of capturing considerable variation which predicts rangeland responses, they often maintain large amounts of variation with them (Lavorel et al. (2007), Funk et al. (2017)). And we believe that additional functional groups warrant attention in our area. As mentioned above C3 and C4 grasses have different responses to many environmental cues. Sprouting and non-sprouting shrubs differ widely in their responses to wildfire, and sites require different post fire management strategies. Annual and perennial forbs (life cycles), differ in their responsiveness to precipitation, with annuals declining rapidly in times of low precipitation.

Methods

Non-vascular plants mentioned ....

References

Archer, S. R., & Predick, K. I. (2014). An ecosystem services perspective on brush management: Research priorities for competing land-use objectives. *Journal of Ecology*, *102*(6), 1394–1407.

Belnap, J., & Sherrod, S. K. (2008). Soil amendment effects on the exotic annual grass bromus tectorum l. And facilitation of its growth by the native perennial grass hilaria jamesii (torr.) benth. In *Herbaceous plant ecology* (pp. 345–357). Springer.

Corbin, J. D., & D'Antonio, C. M. (2004). Competition between native perennial and exotic annual grasses: Implications for an historical invasion. *Ecology*, *85*(5), 1273–1283.

Diaz, S., Lavorel, S., McIntyre, S., Falczuk, V., Casanoves, F., Milchunas, D. G., Skarpe, C., Rusch, G., Sternberg, M., Noy-Meir, I., et al. (2007). Plant trait responses to grazing–a global synthesis. *Global Change Biology*, *13*(2), 313–341.

Eldridge, D. J., Poore, A. G., Ruiz-Colmenero, M., Letnic, M., & Soliveres, S. (2016). Ecosystem structure, function, and composition in rangelands are negatively affected by livestock grazing. *Ecological Applications*, *26*(4), 1273–1283.

Funk, J. L., Larson, J. E., Ames, G. M., Butterfield, B. J., Cavender-Bares, J., Firn, J., Laughlin, D. C., Sutton-Grier, A. E., Williams, L., & Wright, J. (2017). Revisiting the h oly g rail: Using plant functional traits to understand ecological processes. *Biological Reviews*, *92*(2), 1156–1173.

Lavorel, S., Diaz, S., Cornelissen, J. H. C., Garnier, E., Harrison, S. P., McIntyre, S., Pausas, J. G., Perez-Harguindeguy, N., Roumet, C., & Urcelay, C. (2007). Plant functional types: Are we getting any closer to the holy grail? In *Terrestrial ecosystems in a changing world* (pp. 149–164). Springer.

Maestre, F. T., Eldridge, D. J., Soliveres, S., Kefi, S., Delgado-Baquerizo, M., Bowker, M. A., Garcia-Palacios, P., Gaitan, J., Gallardo, A., Lazaro, R., et al. (2016). Structure and functioning of dryland ecosystems in a changing world. *Annual Review of Ecology, Evolution, and Systematics*, *47*, 215.

McIver, J., Grace, J. B., & Roundy, B. (2022). Pion and juniper tree removal increases available soil water, driving understory response in a sage-steppe ecosystem. *Ecosphere*, *13*(11), e4279.

Munson, S. M., Belnap, J., & Okin, G. S. (2011). Responses of wind erosion to climate-induced vegetation changes on the colorado plateau. *Proceedings of the National Academy of Sciences*, *108*(10), 3854–3859.

Pennington, V. E., Schlaepfer, D. R., Beck, J. L., Bradford, J. B., Palmquist, K. A., & Lauenroth, W. K. (2016). Sagebrush, greater sage-grouse, and the occurrence and importance of forbs. *Western North American Naturalist*, *76*(3), 298–312.

Sheley, R. L., & James, J. (2010). Resistance of native plant functional groups to invasion by medusahead (taeniatherum caput-medusae). *Invasive Plant Science and Management*, *3*(3), 294–300.

Wilson, S. D., Schlaepfer, D., Bradford, J., Lauenroth, W., Duniway, M., Hall, S., Jamiyansharav, K., Jia, G., Lkhagva, A., Munson, S., et al. (2018). Functional group, biomass, and climate change effects on ecological drought in semiarid grasslands. *Journal of Geophysical Research: Biogeosciences*, *123*(3), 1072–1085.