The illusion of control: Spatial and temporal variability greatly exceed experimental treatment effects on grassland community composition

OR

The illusion of control: an assessment of the magnitude and predictors of compositional variation in grasslands around the globe

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Updates:

* Re-wrote results section to reflect new figure order, question structure, and removed the cluster analysis
* Reordered the data analysis section to reflect to figure order and removed cluster.
* Reordered figures, adding in new Figure 2 and kept figure S2 in the supplemental.
* Added Figure XX for consideration. This shows magnitude of compositional variation vs. percent due to turnover. Note that sites span all four quadrats (high compositional variation with high turnover, high compositional variation with low turnover, low compositional variation with high turnover, and low compositional variation with low turnover).

# Abstract (current 331 words)

Human activities are dramatically altering species diversity and composition of plant communities around the world. Typical approaches to detecting and predicting these impacts involve experiments comparing controls to treated plots, assuming spatial and temporal homogeneity of controls. However, natural ecosystems are known to be highly dynamic, and violations of these assumptions – if not accounted for – affect our ability to capture plant community responses to global change. We analyzed abundance- and incidence-based metrics of plant community composition at 49 grassland sites in 14 countries to examine the magnitude of within-site compositional variation and its drivers. Each site had an identical experimental and sampling design: 8 nutrient addition treatments x 24 plots x 4 years (pre-treatment plus 3 years post-treatment). We examined the relationships between each of these composition metrics and multiple site-level explanatory variables (management history, gamma diversity, plant productivity, local variation in productivity, and climate variables). Finally, we quantified how the variation within each site was partitioned among spatial, temporal, and treatment-related sources. Overall, compositional change was considerable, with much of the total variation attributed to spatial variation among plots in the pre-treatment year and temporal variation in control plots, rather than driven by treatment effects. Hence, the underlying assumption of stable control plots as well as the homogeneity of the landscape was an illusion. Compositional change was due more to changes in the dominant species relative to rare species. The site-level species pool (gamma diversity) was a key driver of compositional variation, particularly in terms of how much of the change was due to species turnover. Productivity, local variation, annual temperature range, and mean annual precipitation were also important for different aspects of compositional variation. We demonstrate it may be difficult to detect the effects of experimental treatments in sites where spatial and temporal variation are considerable, and may increase the occurrence of type 2 errors where variable controls may mask the effects of treatments.