2012 LTER Cross-Site Synthesis Grant Final Report

Title: Temporal dynamics of plant community composition in relation to interannual variation in rainfall

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Background:

Understanding how biotic mechanisms confer stability in variable environments, and the conditions under which they operate, is a fundamental quest in ecology that is becoming increasingly urgent with global change. Most research on the relationship between population and community stability has centered on the degree to which fluctuating populations exhibit compensatory dynamics, which act to stabilize the overall community (Ives et al. 1999, Gonzalez and Loreau 2009). Compensatory dynamics occur when asynchronous population fluctuations (or negative covariance, as one species declines in abundance, another increases) result in stability at the community level (Gonzalez and Loreau 2009). In variable environments, environmental forcing may drive compensatory dynamics if co-occurring species have differential responses to environmental conditions (e.g., one species increases in abundance while another decreases in response to rainfall variability), leading to asynchronous population dynamics (Tilman 1996, Yachi and Loreau 1999). While widely-assumed theoretically, empirical evidence for compensatory dynamics remains elusive. Some studies confirm the presence of compensatory dynamics and its links to community stability (Descamps-Julien and Gonzalez 2005, Vasseur and Gaedke 2007, Downing et al. 2008, Leary and Petchey 2009), but recent data synthesis studies have questioned the widespread existence of these dynamics in natural systems (Houlahan et al. 2007, Mutshinda et al. 2009).

Compensatory dynamics indicated by negative species covariance is only one of several mechanisms that can maintain community stability. Indeed, stability and the mechanisms that maintain it likely vary in importance across environmental gradients (Bai et al. 2004, Grman et al. 2010). For instance, community stability can be maintained by stability in population-level responses (Roscher et al. 2011). This second mechanism may be particularly important when dominant species, which make up the majority of primary production, buffer environmental fluctuations through stability in vital rates and remain good competitors over time (Smith and Knapp 2003, Hobbs et al. 2011, Sasaki and Lauenroth 2011). The goal of our cross-site synthesis was to contextualize biotic stability mechanisms in light of environmental variability. Precipitation variability is a well-documented driver of spatial and temporal dynamics in ecological communities (Tilman and Downing 1994, Knapp and Smith 2001, Huxman et al. 2004). We hypothesized that in sites characterized by weaker precipitation variability, ecosystem function is maintained by the stable presence of a few dominant species. In contrast, we hypothesized that negative species covariance may be the primary stability mechanism in systems characterized by stronger precipitation fluctuations (Yachi and Loreau 1999).

<u>Summary of activities:</u>

In 2012 our group was funded by an LTER cross-site synthesis grant, including funds for a Graduate Student Researcher (Akana Noto) to augment existing species composition and climate datasets to include additional sites. We held our first meeting at UC Berkeley in June and held a second meeting during the LTER All Scientists Meeting in Estes Park in September.

We also held a public ASM session to disseminate results from our cross-site synthesis efforts, and gain feedback from the wider LTER community. This was well attended by roughly 40 researchers and we brainstormed additional future research activities that would involve new collaborators from this audience.

We made significant progress towards our research goals. We synthesized climate and species composition data from 8 LTER sites and 4 additional non-LTER sites (see Table 1). Our primary resulting manuscript documents high levels of compensatory community dynamics across our focal sites, and demonstrates that strength of these dynamics increase with precipitation variability. In contrast, it shows that the stability of dominant populations was a key mechanism in sites characterized by weaker precipitation variability (Hallett et al. in review). Our results support a previous study within one LTER site (KBS) that described biotic mechanisms varying with the environmental context. This manuscript is the first document this pattern broadly across U.S. grasslands.

<u>Products:</u>

Hallett et al. (2012) Compensatory dynamics increase along a gradient of precipitation variability in US grasslands. Oral Presentation, Annual Meeting of the Ecological Society of America, Portalnd Oregon, August 2012.

Hallett, L. M., J. S. Hsu, E. E. Cleland, S. L. Collins, T. Dickson, E. Farer, K. Gross, L. Gherardi, L. Turnbull, and K. N. Suding. *in review*. Biotic mechanisms of ecosystem stability change with precipitation variability.

Table1: Focal sites and years for which we assembled paired species composition and climate datasets. Our focal sites spanned a large gradient of mean annual precipitation (MAP). Most are LTER sites, but our synthesis also included 4 non-LTER sites (*). Our working group is still performing analyses with this database, but it is available for additional synthesis research by contacting the PIs.

Site	Community type	Data timeframe	MAP (mm/yr)
SEV	Chihuahuan Desert	1989-present	250
JRN	Chihuahuan Desert	1981-present	255
MON*	Montana grassland	1933-1945	290
SGS	Shortgrass steppe	1983-2007	322
CAR*	Carpenteria salt marsh	1994-2008	380
HAY*	Kansas prairie	1937-1972	590
CDR	Old field/savanna	1982-present	660
JRG*	Serpentine grassland	1988-present	684
KNZ	Tallgrass prairie	1984-present	835
KBS	Old fields/savannas	1990-present	890
NWT	Alpine tundra	2002-present	1045
GCE	Atlantic salt marsh	1996-present	1300

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