# Introduction

1. Framing: Energetic compensation, complementarity, and shifting conditions
   1. Energetic compensation (EC) can occur within an assemblage when declines in the abundance of one species or group of species are offset by gains from other species, such that the total proportion of available resources being used by the assemblage remains unchanged. When observed, energetic compensation is consistent with a zero-sum competitive dynamic, and by definition renders assemblage-level function (in terms of resource use) resilient to fluctuations at smaller levels of organization.
   2. For EC to occur, all or at least some of the species in an assemblage must be sufficiently similar in their resource use and broader environmental requirements that replacement species can increase in abundance to absorb resources made available due to declines in other species. This may happen via neutrality - if all species in an assemblage are functionally identical - or via functional redundancy or complementarity in a niche-structured community. That is, while species are unlikely to be fully identical in all dimensions of their niche requirements, there may be areas of partial overlap that allow for EC.
   3. When EC occurs via functional complementarity in a niche-structured system, it is contingent on biotic and abiotic conditions allowing similar but not identical species to functionally substitute for each other. If these species differ in their responses to shifting environmental conditions, EC may wax and wane as conditions change, even within the same set of species. This would mean that zero-sum dynamics (and their effects on community structure and evolution) are intermittent over time, and that the stability of assemblage-level function fluctuates with shifting conditions.
2. Empirical approaches to EC
   1. EC is challenging to detect in observational timeseries. [May reference compensatory dynamics lit here]
   2. Some of the strongest evidence regarding EC comes from long-term experimental manipulations of desert rodent communities. When observed in these systems, EC appears to be niche-structured and determined in large part by the species and traits available in the assemblage. (Kelt, Ernest)
   3. At Portal, very weak energetic compensation occurred in the first 16 years following kangaroo rat removal. Smaller granivores increased in abundance on exclosure relative to treatment plots, but only compensated ~15% for the missing kangaroo rats. In the late 1990s, a new species of pocket mouse, PB, established at the site. PB became the dominant species on exclosure plots, and, driven by its high abundances, small granivore compensation for kangaroo rats increased to ~70%. PB is more similar in size to kangaroo rats than other small granivores and competes with them strongly, suggesting that it shares similar traits, particularly related to resource use, to kangaroo rats. While these traits were missing from the exclosure plots, EC was not possible, but once they joined the assemblage, EC occurred.
3. Shifting conditions at Portal
   1. PB’s establishment at the site, and the resulting EC, coincided with major environmental transitions. Over the 1980s and 1990s, and especially following a period elevated winter rainfall associated with the early 1990s El Nino cycle, shrub cover increased dramatically at the site, as did the relative abundance of shrubland-associated rodent species. While it has never been clear why PB established at the site when it did, PB has also been reported to like bushy habitat (old studies), and the transition to shrubland may have made it possible for dispersing individuals to establish a population at the site in the mid-1990s. Finally, PB’s dominance at the site was firmly established following a period of drought, which may have overcome incumbency effects favoring long-term resident species.
   2. Other reorganization events at the site have also corresponded with a combination of gradual and rapid environmental shifts. The decline of DS coincided with a transition from grassland to shrubland, combined with sheet flooding from tropical storm Octave (Brown and Valone). Among the plant community, the invasive Erodium established at the site in the mid-1990s, again possibly aided by shifting climate and plant community conditions (Allington).
   3. The most recent such reorganization event, and the first to occur since PB rose to dominance, occurred following a severe drought in 2010.Following the drought, PB declined precipitously, to near-absence on control plots (Christensen).
4. Here we investigate:
   1. How the decline in PB has affected the EC response observed in the 1990s-2000s
   2. We also performed descriptive, exploratory analyses on the local climate and plant community dynamics to contextualize how conditions have shifted at the site.

**Methods**

1. Data and time periods
   1. Rodent data from 1988-2020: longest period of continuous plot treatments. Only longterm plots.
   2. Split the timeseries into three time periods: 1988-1996 (pre-PB), 1996-2010 (PB dominance), and 2010-2020 (post-changepoint). Explore the sensitivity to different division points.
2. Rodent community energy use
   1. For all variables, pool plots of the same treatment and look at the dynamics of the treatment-level means. This is necessary to calculate quantities like energetic compensation.
      1. If the between-plot variability becomes a sticking point, I have a GAM method one could argue for. It's not bulletproof, but there isn't a more established method available.
   2. Variables:
      1. PB energy use as a proportion of total energy use on treatments and controls
      2. Energetic compensation on treatments as (SGE\_trt - SGE\_ctrl) / DipoE\_ctrl
      3. Total energy use on treatments as a proportion of total energy use on controls
   3. Compare each of these variables over the different time periods using generalized least squares or generalized linear models.
      1. PB energy use: GLM with quasibinomial link. Time period restricted to 1996-2020, because PB is not present prior to 1996 (and the 0s break the GLM).
      2. Energetic compensation: GLS accounting for temporal autocorrelation
      3. Total energy: GSL accounting for temporal autocorrelation
3. Environmental conditions
   1. Climate
      1. Variables: Precip, temperature, NDVI, drought index (**new**)
      2. Remove seasonality and visualize using GAM.
         1. I lean towards this - simple - analysis being the appropriate place to stop for these purposes. This is a prospective search for suspicious-looking changes leading up to 2010, without a more specific prior that would guide a statistical analysis.
            1. (That said, I’ve explored more sophisticated approaches, but have not gotten a lot of traction with them. Specifically, some kind of multidimensional climate envelope is tricky with just a few, highly correlated variables and no strong prior on how to break up the timeseries. One could fit breakpoints to the univariate timeseries, but I’m not convinced this tells you much you don’t get from just looking at them.)
   2. Plants
      1. Community composition
         1. PCCoA, LDA
      2. Erodium
         1. Total abundance and proportion of winter annuals. Can just visualize, or fit a quasibinomial GLM.

**Results**

**Discussion**