

# Environmental responses consistently, but not completely, synchronize population dynamics of co-occurring grassland species?

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## Introduction

Asynchrony in population dynamics

## The Neutral Expectation

Before calculating and interpreting community synchrony, it is helpful to explicitly define the null hypothesis against which observed synchrony will be compared. Unlike some previous studies, we start with the neutral expectation that coexisting species within the same trophic level should fluctuate in perfect synchrony.

Previous work to assess the ubiquity of asynchronous or compensatory dynamics (e.g., Houlahan) in natural communities has suffered from three flaws: (1) they lacked a synchrony metric that does not rely on pair-wise comparisons (see Brown et al. 2004 for critique summed negative covariances), (2) they compared observed synchrony to the biologically unrealistic null hypothesis of independent species fluctuations, and (3) they used population size, or proxies thereof, to calculate synchrony rather than per capita population growth rates that reflect the environmental forces governing population dynamics from one generation to the next.

## 20 Methods

21 We built environmentally and demographically stochastic multi-species integral projection  
22 models (IPMs) to simulate species' dynamics through time. The IPMs are based on vital  
23 rate regressions for survival, growth, and recruitment (Chu and Adler 2015). Environmental  
24 stochasticity is incorporated by fitting random year effects for the intercept of all regressions  
25 and on the plant size effect in the survival and growth regressions. Thus, for a fluctuating  
26 environment we can randomly draw year-specific regressions for each time-step of the IPM.  
27 Alternatively, to simulate the community in a constant environment we can use the mean  
28 regressions for each species. We incorporate demographic stochasticity in the IPM by making  
29 survival a binomial process (see Vindenes et al. 2011). We can remove demographic stochastic-  
30 ity by treating survival as a continuous rather than binomial process, as is traditionally done  
31 with IPMs (e.g., Rees and Ellner 2014).

32 To determine the (de)synchronizing effects of demographic stochasticity and species' responses  
33 to the environment we simulated communities using the IPM under three scenarios: (1)  
34 demographic and environmental stochasticity included, (2) demographic stochasticity removed,  
35 and (3) environmental stochasticity removed. We ran simulations for 2,500 time steps and  
36 calculated  $\phi_r$  using the final 1,000 time steps. For each of our study sites we then calculated  
37  $\Delta(\phi)$ , the difference between either scenarios 2 or 3 and the unperturbed scenario 1. The sign  
38 and magnitude of  $\Delta(\phi)$  indicates the (de)synchronizing effect of removing either demographic  
39 or environmental stochasticity.

## 40 Results and Discussion

41 Synchrony of per capita growth rates among species in each community were in the range  
42 ## - ## with an average synchrony of ## (Table #). If our null expectation had been  
43 independent fluctuations, then we would conclude that these communities are far from  
44 exhibiting asynchronous dynamics. However, based on neutral theory, we expected the species

45 to fluctuate in perfect synchrony. Thus, our results show that these communities exhibit  
 46 weak asynchrony since any asynchrony in temporal dynamics drives  $\phi_r$  away from zero.

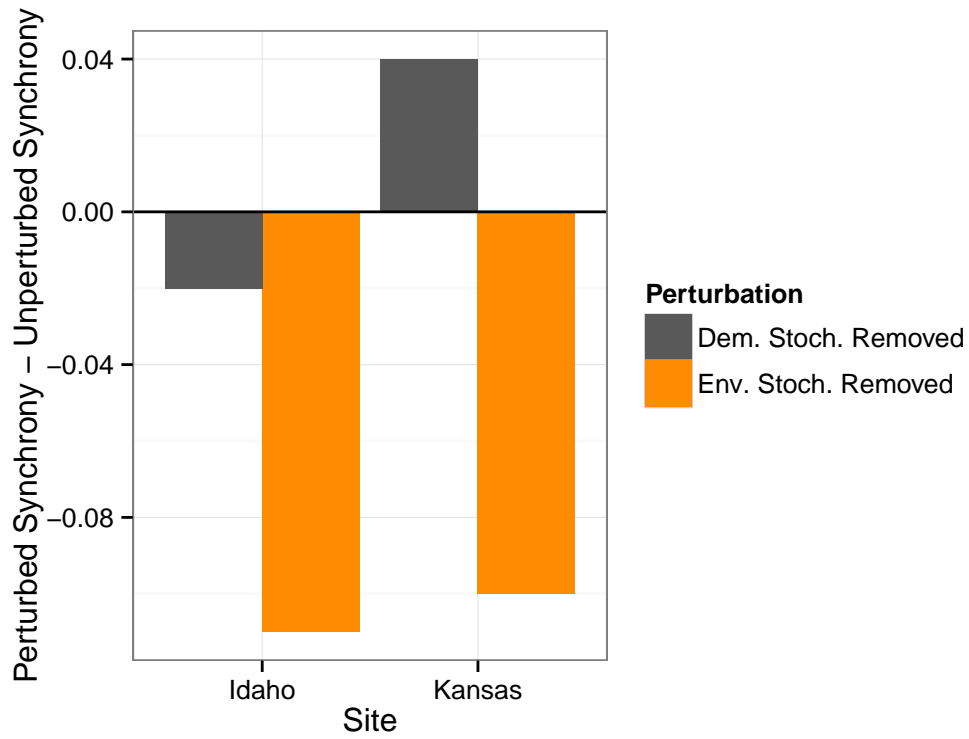


Figure 1: Effect of removing demographic and environmental stochasticity on the synchrony of population dynamics.