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Turnover and reliability of flower communities in extreme environments: Insights from long-term phenology data sets

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ABSTRACT

We used three long-term data sets from the southwestern US to investigate the reliability of flowering communities from the perspective of pollinators in extreme environments. The data sets come from three desert sites in New Mexico, two subalpine sites in Colorado, and an elevation gradient in Arizona. We used two indices to explore different temporal scales. We calculated turnover rates of species in bloom on a seasonal basis to investigate how flowering communities change from year to year. We calculated frequency of bloom in the same month over all years to determine the reliability of flowering communities in a narrow time scale. We hypothesized that communities with less reliable precipitation would have lower frequency of bloom and higher turnover rates and that annual plants would show this pattern more strongly than perennials. Flower frequency ranged from 50.3% at the highest elevation AZ site to 66.3% at a subalpine CO site. Within each site, annuals exhibited lower frequencies than perennials. On a seasonal scale, turnover rates ranged from 22.5% in Colorado to 71.4% at a NM site. Looking at the entire flower community as a resource for foraging pollinators, we found that flowers are an unreliable resource, especially in unpredictable environments.

1. Introduction

Flowering phenology plays an important role in the structuring of plant communities as well as the consumers that depend on them. These community-level patterns are affected by their component plant species which have different levels of flowering reliability. Plant phenology studies have long sought to discern which environmental cues yield observed phenological patterns of various individual plant species (Abd El-Ghani, 1997; Adondakis and Venable, 2004; Berlin et al., 2000; Bowers, 1987; Bowers and Dimmitt, 1994; Friedel et al., 1993, 1994; Lambert et al., 2010; Miller-Rushing and Primack, 2008; Pavon and Biones, 2001), related species (Miller-Rushing and Inouye, 2009), or all species in a community (Beatley, 1974; Crimmins et al., 2010; Kemp, 1983).

Plants are sometimes constrained by their phylogeny or evolutionary history (Franks et al., 2007; Kochmer and Handel, 1986; Willis et al., 2008), but many species also exhibit flexibility in their life history to survive climate fluctuations (Willis et al., 2010). At the community level, no two species of plants (Beatley, 1974), not even congeners (Miller-Rushing and Inouye, 2009), respond identically to the array of environmental cues. At the population level, there is a wide range of individual responses, most likely due to a combination of microclimate variability, genetic variation and phenotypic plasticity. All of these factors come together to make the flowering community apparently stochastic from year to year, especially where environmental conditions fluctuate markedly such as in deserts and subalpine areas (Holway and Ward, 1963; Huelber et al., 2006; Kudo and Hirao, 2006). The projected increase in climate variability in the southwest (Overpeck and Udall, 2010; Sheppard et al., 2002) may result in increased variability in phenology in the future.

Few phenology studies look at all species in a community and only a handful of studies have examined the community of flowers from a resource availability perspective (Alarcón et al., 2008;

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