**Title:**

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**Abstract**

**Key words**: heterogeneity, desert rodents, patch preference

**Introduction**

Paragraph 1:

Paragraph 2:

Paragraph 3:

**Methods**

***Study System and Data***

We used a 26-year time series (1988 – 2014) of capture-mark-recapture rodent data collected from the Portal Project to calculated population-, community-, and ecosystem-level metrics through time. The Portal Project, started in 1977, is a long-term experimental system in the Chiricahua desert, near Portal, Arizona, USA (Brown et al. 1998). Rodent abundance and composition data are collected monthly using Sherman live traps, continuing to add to over 40 years of monthly rodent data [living data paper?]. The site consists of 24 50x50 m fenced plots with three designated treatments. In control plots (*n* = 10), holes cut in the fence are large enough to allow all rodent species access while full rodent removal plots (*n* = 6) have no gates. Kangaroo rat exclosure plots (*n* = 8) have small holes in the fences which allows passage of all rodents except for those in the *Dipodomys* genus, which have enlarged auditory bullae; being able to selectively exclude *Dipodomys* is particularly useful as *Dipodomys* species are typically behaviorally dominant in the system [citation?]. Each plot consists 49 evenly-spaced permanent trapping stations placed in a 7x7 grid. We identify to species, measure and record size and sex characteristics, and give each rodent an individualizing marker; in the past, toe and ear tags were used, but we now exclusively use passive integrated transponder (PIT) tags.

To ensure quality of data, we performed extensive quality control and cleaning of the data to address potential issues (e.g. duplicate tags, uncertain species identification). Where individuals with identical tags could be determined to be unique individuals (based on time between capture or different species identifications), each individual was assigned a unique tag number for analysis. Those considered indeterminant were excluded from analysis.

***Analyses***

All data and code for this paper is available on Github (<https://github.com/weecology/PortalData> and <https://github.com/bleds22e/PP_shifts>, respectively).

*Patch Preference in Response to C. baileyii*

To determine how *C. penicillatus* abundance in control plots and kangaroo rat exclosures differed from equal through time, we fit a linear model along the 1:1 line of mean *C. penicillatus* per plot by year in kangaroo rat exclosures against control plots. We then fit a quadratic generalized least squares model (`nlme` package) of mean *C. baileyii* per plot by year against the resulting residuals from the previous model to investigate how *C. baileyii* mean abundance relates to *C. penicillatus’s* plot treatment preferences. We compared this model to one with an autroregressive structure. Both models performed similarly, so we chose to use the original model without an autoregressive structure because it had a slightly lower AIC value and was the most parsimonious model.

*Population-level Metrics*

We used three population-level metrics from *C. penicillatus*, in each treatment type to support our findings: survival (*S*), transition probability (Ψ), and the average number of new individuals. Both survival and transition probability were derived from a multistrata model in `RMark`, with each treatment type representing a different stratum. Within the model, each time period was designated as either before or after the infiltration of *C. baileyii* into the system; the first trapping period in which *C. baileyii* was caught in all 8 kangaroo rat exclosures (July, 1997) was used as the differentiating timepoint.

New *C. penicillatus* individuals are not necessarily juveniles or immigrants into the system but those which have been caught and given an identification tag for the first time. We calculated mean new *C. penicillatus* individuals per plot by year; new individuals, therefore, are counted only in the year of their capture.

*Ecosystem Functioning*

As shown in Ernest & Brown (2001), the presence or absence of *C. baileyii* can have substantial effect on ecosystem functioning. We calculated total rodent biomass per year for both plot treatment types and then calculated the ratio between the kangaroo rat exclosures and control plots.

**Results**

*Patch Preference in Response to PB*

Positive residuals from the model indicate that *C. penicillatus* were found in higher numbers in kangaroo rat exclosure plots, and negative residuals indicate higher average numbers in control plots.

*Population-level Metrics*

*Ecosystem Functioning*

**Discussion**

**Acknowledgments**

**Figures**

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| **C:\Users\ellen.bledsoe\Dropbox (UFL)\Grad_School\Projects\PP_shifts\figures\ms_figures\PB_patchwork.png** |
| **Figure 1.** *C. penicillatus* (PP) residuals against the 1:1 line and their relation to *C. baileyi* (PB) abundance. (A) Average number of *C. baileyi* individuals per plot through time. (B) Residuals of a linear model fit to the 1:1 line of average number of *C. penicillatus* individuals per plot in kangaroo rat exclosures versus control plots through time. Positive (+) residuals indicate higher average individuals on kangaroo rat plots than equal, and negative  (-) residuals indicate higher average individuals on control plots. In plots (A) and (B), grey bars indicate infiltration (1995-1998) and subsequent decline (2008-2010) of *C. baileyi.* (C) Generalized least squares regression of *C. penicillatus* residuals as related to the average number of *C. baileyi* individuals per plot per year. [insert stats here] |

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| **Figure 2.** Average number of new *C. penicillatus* (PP) individuals per plot through time. Grey bars indicate infiltration (1995-1998) and subsequent decline (2008-2010) of *C. baileyi.* |

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| **C:\Users\ellen.bledsoe\Dropbox (UFL)\Grad_School\Projects\PP_shifts\figures\ms_figures\biomass_ratio.png** |
| **Figure 3.** Ratio of total rodent biomass in kangaroo rat exclosures to control plots though time. Grey bars indicate infiltration (1995-1998) and subsequent decline (2008-2010) of *C. baileyi.* |

**Tables**

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| Table 1. | | | | |
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| **Time Period** | **Survival (SE)** | | **Transition Probability (SE)** | |
|  |  |  |  |  |
|  | *Control* | *Exclosure* | *Control to Exclosure* | *Exclosure to Control* |
|  |  |  |  |  |
| *Pre-Arrival* | 0.84 (0.01) | 0.85 (0.01) | 0.03 (0.01) | 0.04 (0.01) |
| *Post-Arrival* | 0.82 (0.00) | 0.83 (0.01) | 0.01 (0.00) | 0.02 (0.00) |
|  |  |  |  |  |

**Literature Cited**

Ernest & Brown 2001 *Science*

Laake, J. L. (2013). *RMark: An R Interface for Analysis of Capture-Recapture Data with MARK*. AFSC Processed Rep 2013-01, 25p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle, WA 98115.

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