Paper: A spatially explicit hierarchical model to characterize population viability. *Ecological Applications*

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Description: This README file describes the R script and data used to produce spatially explicit estimates of demographic rates and viability for Sonoran desert tortoises across the species' range in Arizona, USA.

Files:

Spatial_PVA_for_Sonoran_desert_tortoise.r: This R script contains all parts of the PVA model:

- a spatial hierarchical model for estimating survival and transition rates
- estimates of juvenile recruitment (number of one-year-old females produced per adult female per year)
- a stage-structured population model that integrates local demographic rates into estimates of rate of population change
- a simulation model that forecasts local viability using the estimated rate of population change and its uncertainty.

The R script generates posterior distributions for demographic rates and rates of population change for each grid cell, estimates of viability for each grid cell, and ASCII grid files for mapping the estimates in ArcMap or another GIS.

Sonoran_desert_tortoise_enc_hist_data_1977-2008.csv: This file contains encounter histories of 1639 Sonoran desert tortoises from surveys between 1977 and 2008 from 16 sites throughout the species' range in Arizona. Columns are:

- site: two letter site code
- id: identifier of individual tortoise
- sex: sex of tortoise (M = male, F = female, U = unknown)
- y1977-y2008: encounter status of tortoises in each year from 1977 to 2008 (0 = site was surveyed and tortoise was not encountered, 1 = tortoise was encountered as a juvenile, 2 = tortoise was encountered as an adult, NA = site was not surveyed)
- lat: latitude in decimal degrees for site*
- long: longitude in decimal degrees for site*

*Because the Sonoran desert tortoise is a protected species, we do not provide specific coordinates of the sites where tortoises were found. Instead, we provide the coordinates of the centroids of the 0.25° latitude × 0.25° longitude grid cell in which a site occurs. This effectively obscures the site locations to a 28 km × 24 km area, but does not affect the analysis.

Sonoran_desert_tortoise_recruitment_data.csv: This file contains samples from posterior distributions of a series of recruitment estimates (i.e., number of one-year-old females produced per adult female per year) for Sonoran desert tortoises. Recruitment data were too limited geographically to produce spatially explicit estimates, therefore we applied a single estimate across the entire range. Because data for estimating some components of recruitment were sparse, we also explored the effects of multiple range-wide recruitment estimates on viability. Each column in the file represents 10,000 MCMC samples from the posterior distributions of a given recruitment estimate and is labeled with the mean of the posterior distribution (e.g., the column R_0.32 contains the posterior distribution for recruitment with a mean of 0.32 females per female per year). The methods for estimating range-wide recruitment of Sonoran desert tortoises are described in:

Campbell, S. P., R. J. Steidl, and E. R. Zylstra. 2015. Recruitment of desert tortoises (*Gopherus agassizii* and *G. morafkai*): a synthesis of reproduction and first-year survival. Herpetological Conservation and Biology 10: 583-591.