Integrating Remotely Sensed Data and Ecological Models to Assess Species Extinction Risks under Climate Change

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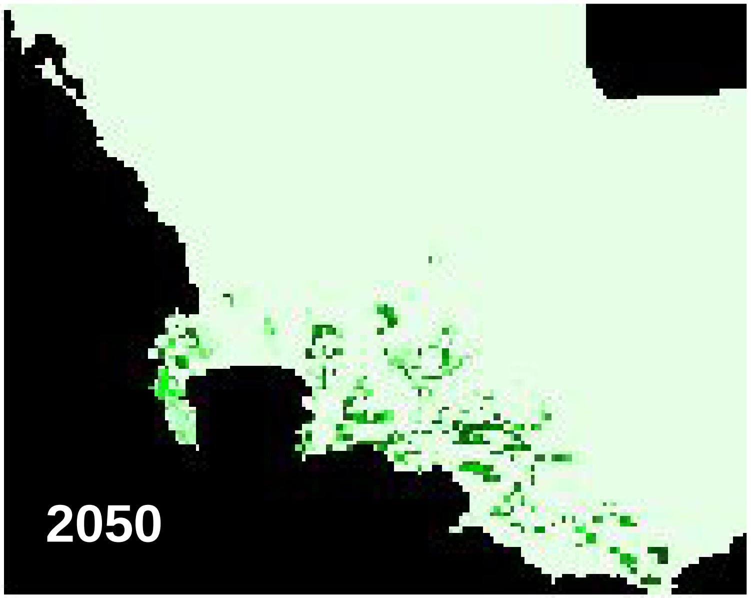
Why: The need for demographic data to assess climate change impacts

Difficulty of inferring extinction risk from range shifts:

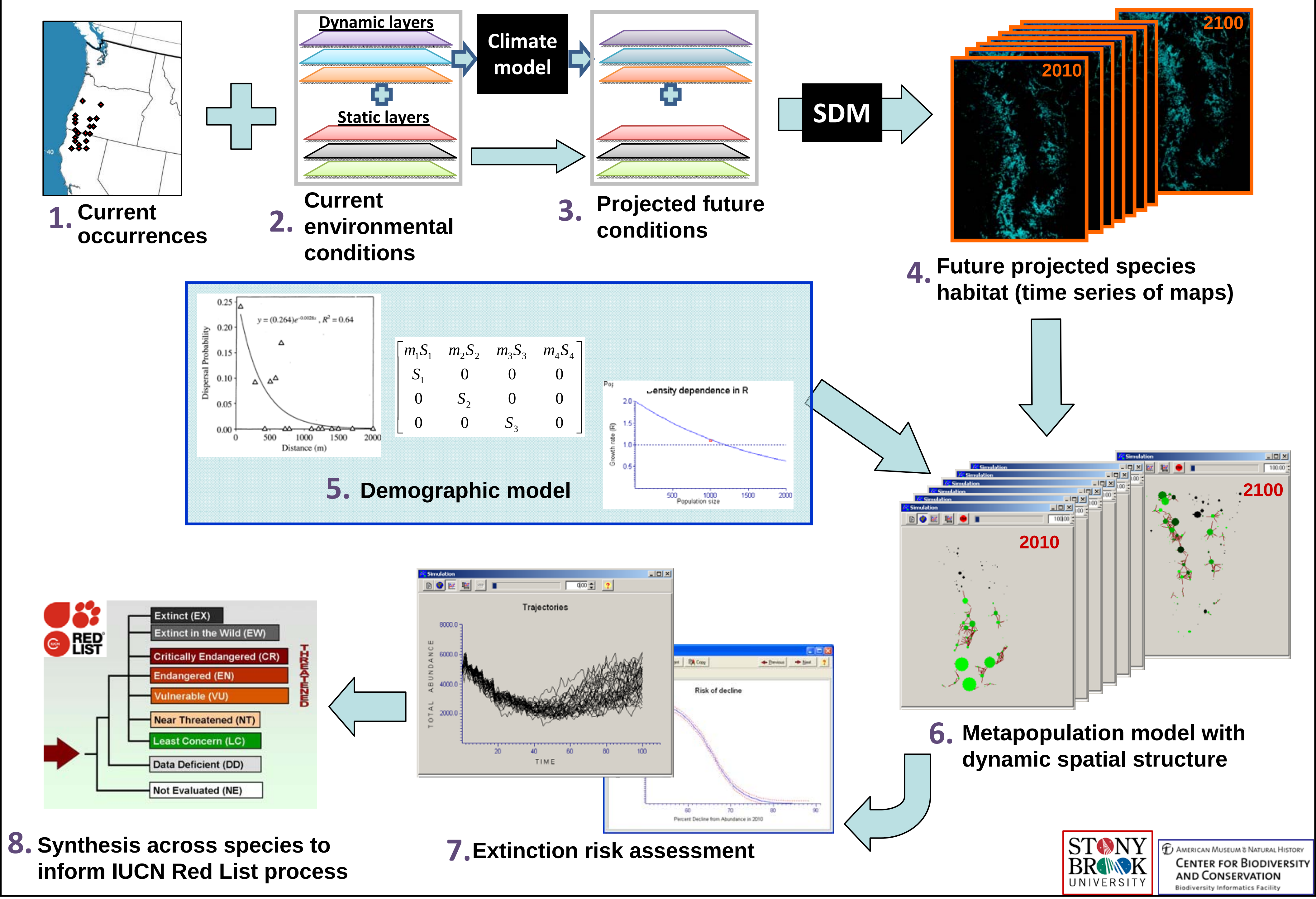
- Dispersal limitations
- Increased fragmentation
- Increased fluctuations
- Time delays in habitat suitability
- Time delays due to population growth
- Behavioral characteristics (e.g. site fidelity)
- Reduced recolonization ability of declining species
- Changes in species interactions



Leucadendron levisanus

Keith et al. 2008, *Biology Letters*

How: An Outline of the Approach



Data & Methods: Climate

- **Baseline (current climate):** monthly 30-arcsecond (~800m) 1971-2000 normals from PRISM climate group, Oregon State University prism.oregonstate.edu
- **Projecting future scenarios**:
  - MAGICC/SCENGEN 5.3 www.cgd.ucar.edu/cas/wigley/magicc to emulate multiple GCMs at regional and local levels
  - Annual time slices, 2010-2100
- **Derived climate variables:** 7 variables based on amphibian and reptile physiology and ecology:
  1. Maximum Temperature of Warmest Month
  2. Minimum Temperature of Coldest Month
  3. Annual Precipitation
  4. Precipitation of Driest Quarter
  5. Mean Temperature of Wettest Quarter
  6. Temperature Seasonality (standard deviation *100)
  7. Precipitation Seasonality (Coefficient of Variation)

Data & Methods: Remote sensing products and other static variables

Land cover

- MRLC National Land Cover Database (http://www.mrlc.gov/)
- 1992 (retrofit), 2001, 2006
- Species EO associated with nearest year
- A separate variable for each land-cover class: proportion of the class (based on 30m resolution data) within ~1km resolution cells

Data & Methods: Remote sensing products and other static variables

Land surface form ("basking potential")

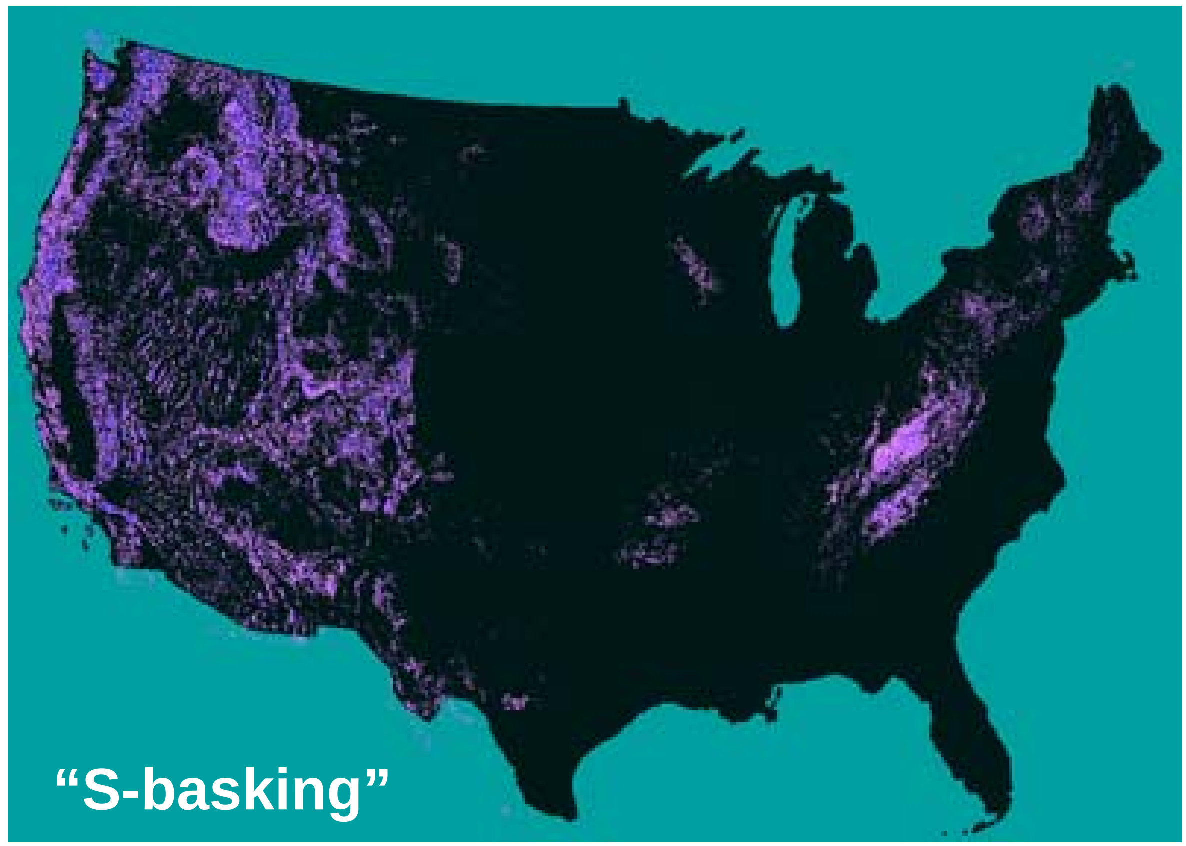
Amphibians cool, moist localities on north facing slopes.

Reptiles: south-facing slopes; neither too shallow nor too steep

(1) Slope: 20 to 60 degrees; Aspect: SE to SW

(2) Slope: 20 to 60 degrees; Aspect: NE to NW

For each ~1km cell, proportion of suitable 30 m cells, based on National Elevation Dataset (ned.usgs.gov), with a 5x5 low pass filter to smooth out artifacts.



Data & Methods: Remote sensing products and other static variables

Hydrography

US National Hydrography Dataset (NHD; http://nhd.usgs.gov)

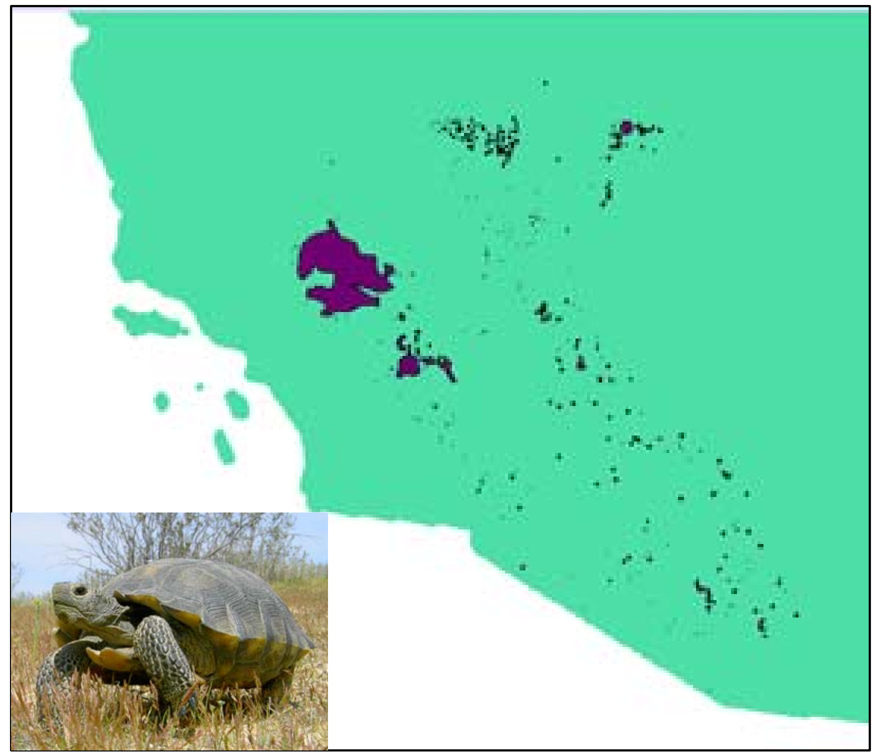
Based on 25-m resolution:

(1) proportion of the ~1 km cell within 200m of standing water

(2) proportion of the ~1 km cell within 200m of moving water

Data: Species occurrence

- Occurrence data for endemic amphibian and reptile species
- NatureServe EO data
- Only post-1990 data used
- Species with<20 EO removed
- Remaining ~40 species: median number of locations=82
- 72% IUCN threatened or NT
- EOs are polygons; 88% of the polygons are $<1km^2$
- Randomly subsampled occurrence records from polygons with sample size=max(1,√Area)



Desert Tortoise

Methods: Predicting species ranges

Ecological niche models with MaxEnt

Calibration: 1971-2000 baseline climate

Projection: Annual time slices for 2010-2100.

Variables:

- All non-climatic variables were kept static (see next slide).
- For each species, set of variables selected based on species' ecology.

Regularization: most suitable based on cross-validation

Background: 10000 random points from the ecoregion(s) of EOs

Combining static and dynamic variables in species distribution models under climate change

Methods in Ecology and Evolution

Methods in Ecology and Evolution doi: 10.1111/j.2041-210X.2011.00157.x

Combining static and dynamic variables in species distribution models under climate change

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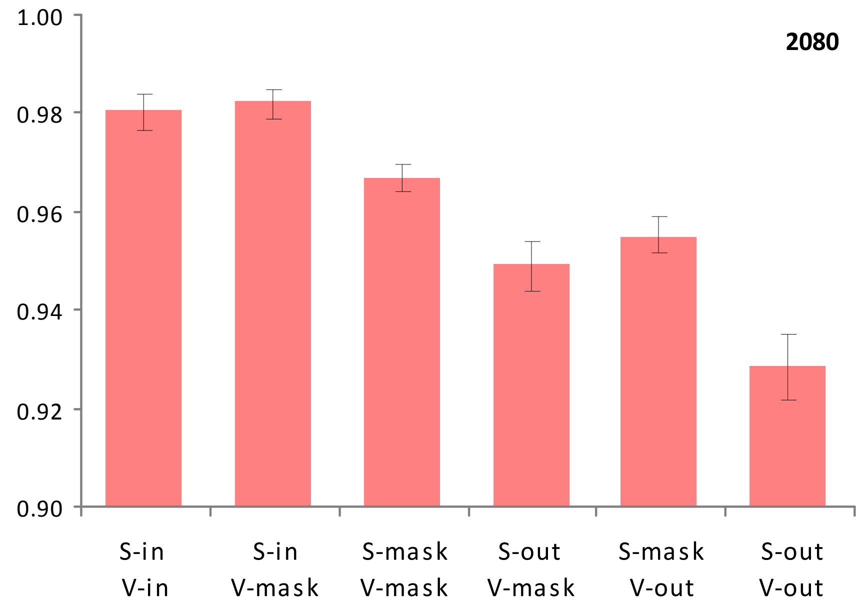

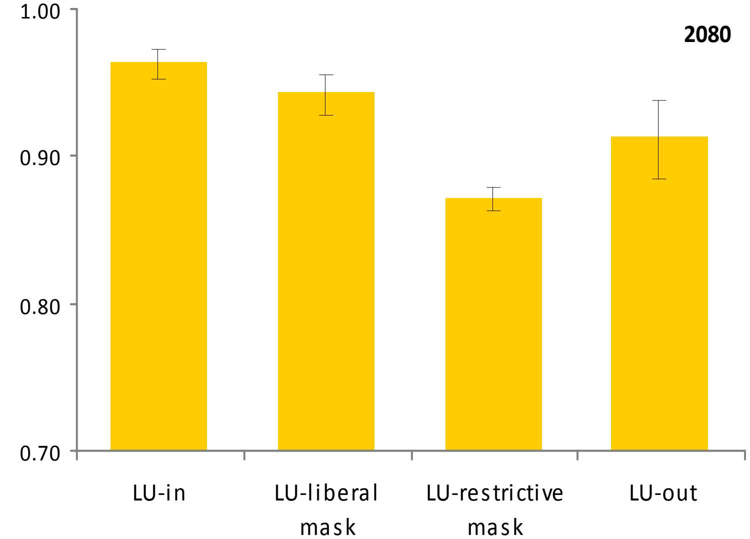

<u>Recommendations:</u>

- static variables highly correlated with climate variables should be **excluded,**
- static variables that interact with climate variables (e.g., soil), should be **included in the model,**
- static variables that do not interact with climate variables can be either **included in the model**, or **used as a mask,**
- dynamic non-climate variables (e.g., land use) can be either **included in the model**, or **used as a mask**, *even if future change in these variables cannot be predicted*, and thus only the current maps can be used.

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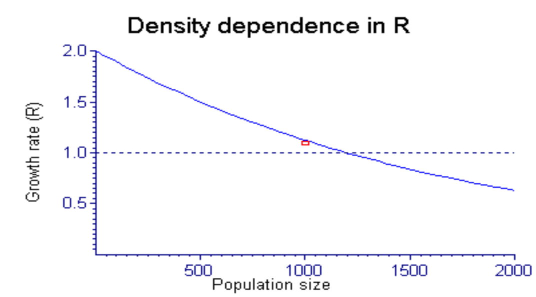
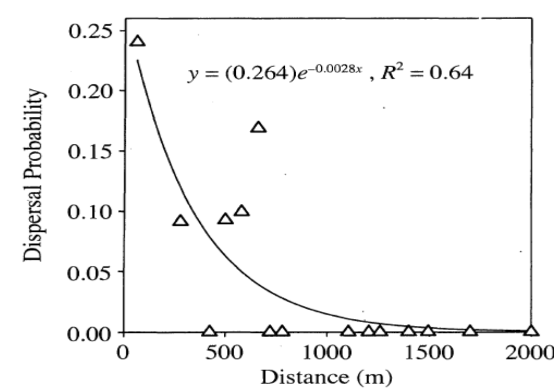
Data & Methods: Life history and population demography

- Generic models for species groups (small salamander, large salamander, tortoise, turtle, snake, lizard)
- Basic life history information:
  - Age/stage/sex structure; survival rates
  - Reproduction (age of 1st breeding; fecundity)
  - Density dependence
  - Dispersal
- Ranges (min & max) for each parameter
- Sampled random models with Latin hypercube (10 per dimension)
- Combine with habitat maps; run simulations; estimate viability

$$\begin{bmatrix} m_1S_1 & m_2S_2 & m_3S_3 & m_4S_4 \\ S_1 & 0 & 0 & 0 \\ 0 & S_2 & 0 & 0 \\ 0 & 0 & S_3 & 0 \end{bmatrix}$$





Next Steps

Currently:

- Creating habitat map time series for each species and each scenario.
- Running simulations with every combination of climate, habitat and demographic models.

40 habitat models
3 climate scenarios
7 life histories
~50 models per combination

A total of ~42,000 models, each ran for 100 years with 1000 replications

Generalization: Statistical analyses (random forests; GLM) to find species' traits and landscape pattern combinations that make species vulnerable to climate change.

Conservation Application: Contribute to the development of guidelines for red-listing species under the IUCN Red List Categories and Criteria.