Regionwide Density Estimates And Habitat Associations Of Alpine Mammal Assemblages In The Sierra Nevada And White Mountains: Implications For Modeling Species Distributions And Population Persistence Under A Changing Climate Scenario

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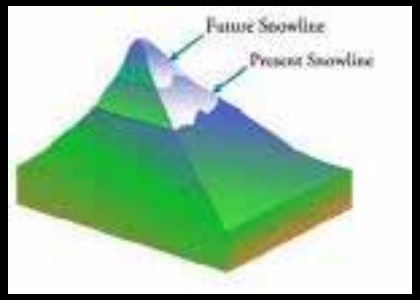
The “Rapture Hypothesis” Scenario

(…with apologies to REM)



- The planet heats up…
- Snowline rises…
- Alpine mammals are trapped…
- Unable to adapt physiologically ….
- Habitat changes…
- Many populations appear doomed to disappear…
- But some may not fall off the mountain

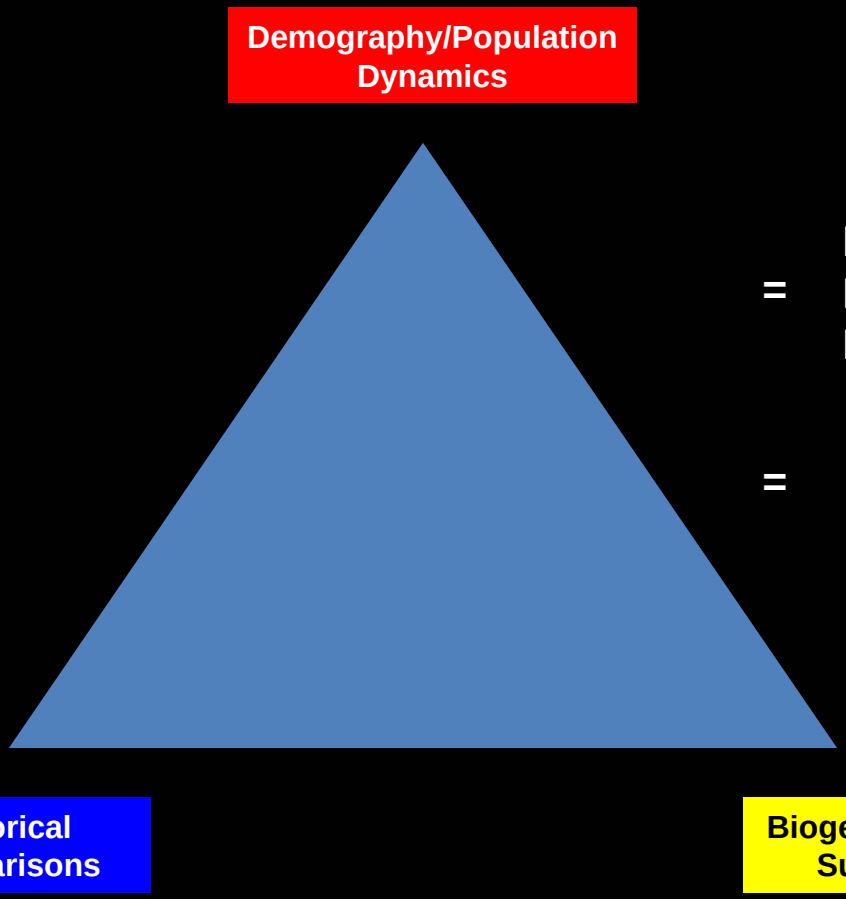
But How Likely Is This Scenario?

- Varying environmental conditions
- Different life history characteristics
- Different habitat association patterns
- Different physiological traits
- Phenotypic and behavioral plasticity
- ***Consistent or variable responses to climatic shifts?***

Data From Western Mountain Ranges

- Historical comparisons
  - *Beever et al. 2003*
  - *Grayson 2005*
  - *Moritz et al. 2008*
- Biogeographical surveys
  - *Beever et al. 2003, 2008*
  - *Floyd 2004*
  - *Floyd et al. 2004, 2005*
  - *Griffin et al. 2008*
  - *Rowe 2007*
- Demography/population dynamics (?)
  - *Bronson 1979 (SNV)*
  - *Sherman & Morton 1984 (SNV)*
  - *Schwartz et al. 1998 (Rockies)*
  - *Kreuzer & Huntly 2003 (Beartooth's)*

The Legs Of The Triangle



= Pattern (extent) +
Process (direct vs. indirect effects) +
Mechanism (prediction)

= Integrated & comprehensive understanding of factors determining persistence

Sierra Nevada/White Mountain Alpine Mammal Study

- 7-10 year study
- Multi-species study
  - Yellow-bellied marmot
  - American pika
  - Belding's ground squirrel
  - Golden-mantled ground squirr
- Multi-scale
  - Regional
  - Local
- Estimate:
  - Occupancy
  - Habitat associations
  - Density
  - Demographic rates

- Model:
  - Population dynamics
  - Species distributions
    - Climate
    - Topography
    - Vegetation
  - Persistence
- Compare:
  - Among species
  - Among mountain ranges
  - Temperature gradient

First Year Data: A Heuristic Exercise

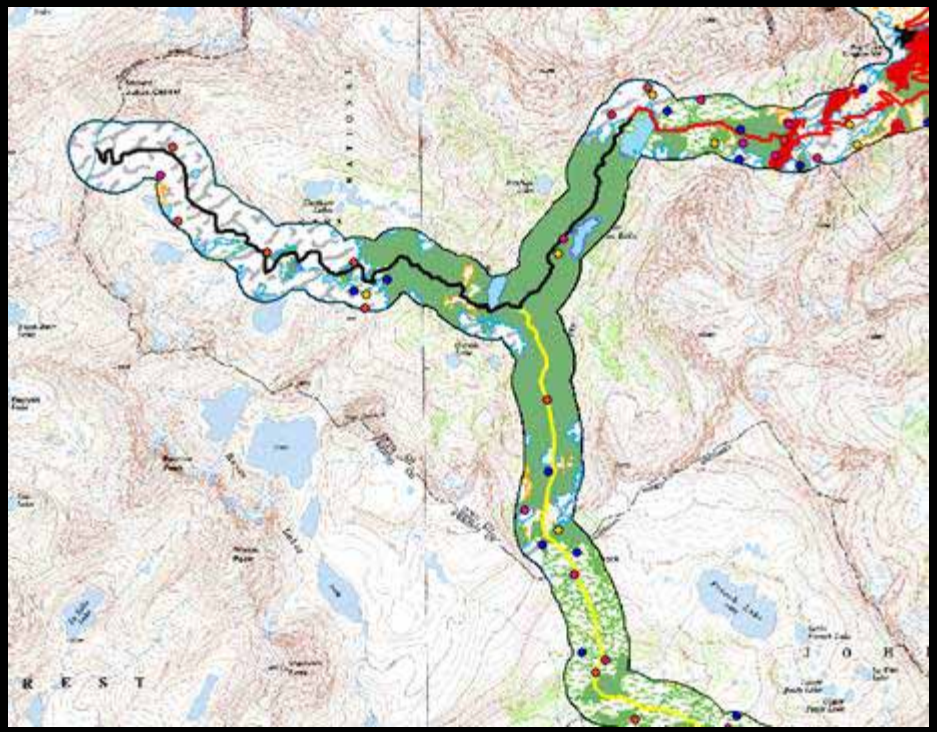
- Density estimates
  - Sierra Nevada and White Mtns.
  - Southern, central, and northern Sierra Nevada
- Occupancy estimates
- Habitat associations
  - Between species
  - Relative to availability

Preliminary Expectations

- If species are responding primarily to temperature/precipitation gradients:
  - Densities lower in White Mtns. than Sierra Nevada
  - Densities in southern Sierra < central Sierra < northern Sierra
- If species are responding primarily to habitat characteristics:
  - No consistent difference in density between geographic strata
- If strong species life-history effects:
  - Significant difference in density among species
  - Significant difference in habitat associations among species

Methods

- Density estimates
  - 40 variable-distance line transects (454 km)
    - 28 Sierra Nevada (368 km)
      - 6 south (72 km)
      - 11 central (169 km)
      - 11 north (127 km)
    - 12 White Mtns. (86 km)
    - June-September
- Occupancy estimates
  - 25 variable-distance point counts
    - 15 Sierra Nevada
    - 10 White Mtns.
    - 6 visits each (June-August)
- Habitat associations
  - Line transect observations
    - 250 m buffer
  - Calveg vegetation layer (GIS)

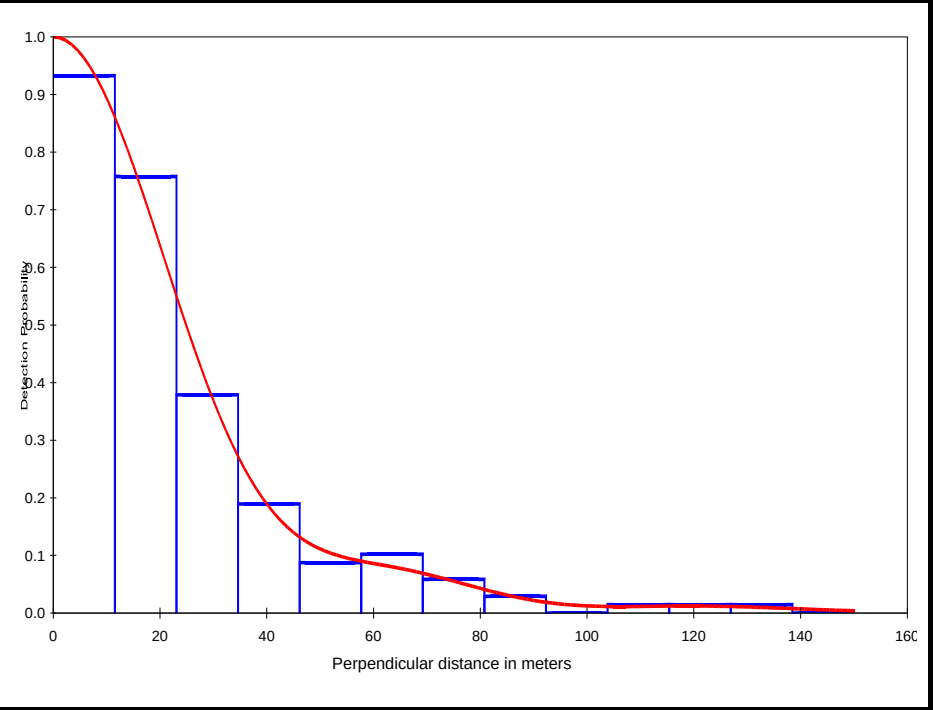


Sample Size

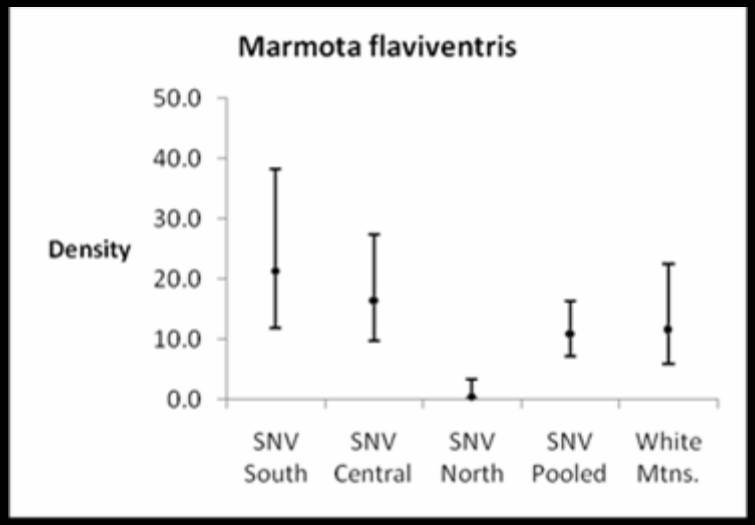
- Density estimates
  - 1206 independent observations
    - Yellow-bellied marmot (N = 355)
    - American pika (N = 230)
    - Belding's ground squirrel (N = 208)
    - Golden-mantled ground squirrel (N = 413)
- Occupancy estimates
  - 719 independent observations
    - Yellow-bellied marmot (N = 189)
    - American pika (N = 176)
    - Belding's ground squirrel (N = 140)
    - Golden-mantled ground squirrel (N = 214)
- Habitat associations
  - 1206 independent observations

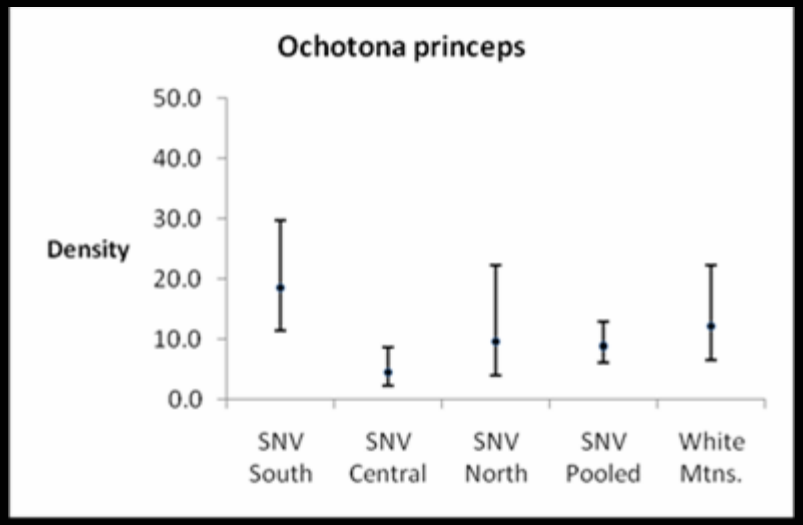
Analysis

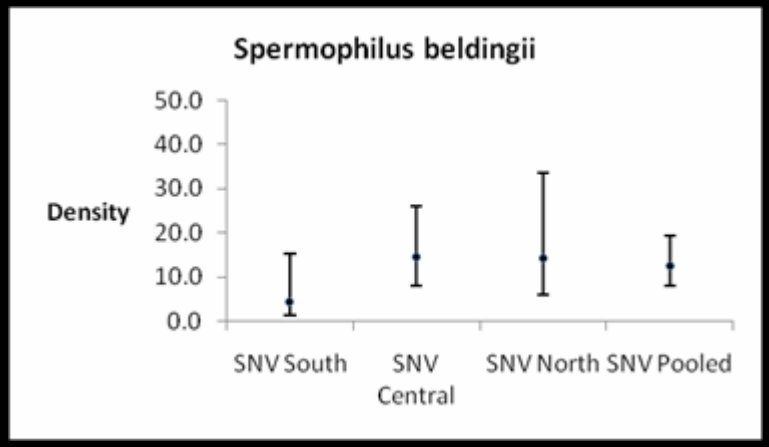
- Density estimates
  - Uniform and half-normal distributions
    - **Cosine and polynomial expansions**
    - **Visual fit and AICc for model selection**
- Occupancy estimates
  - Similar to mark-recapture models
    - **One vs. two-strata models (implies suitable vs. unsuitable areas)**
- Habitat associations
  - Between species
  - Occurrence vs. availability
    - Log-likelihood X^2
    - 95% CI's

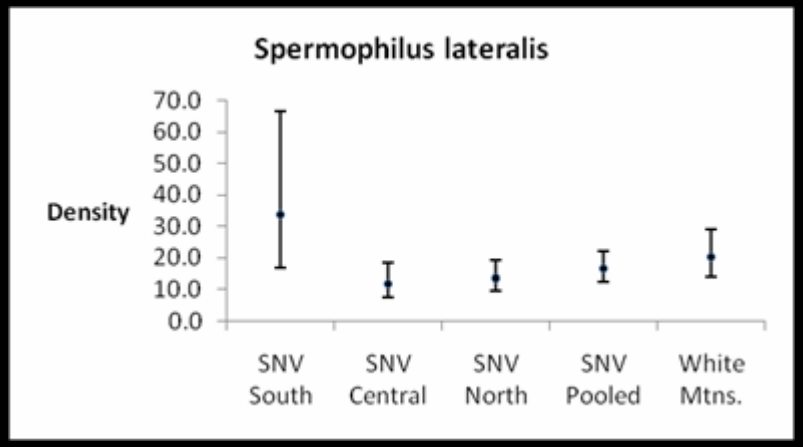


Density Estimates By Geographic Region

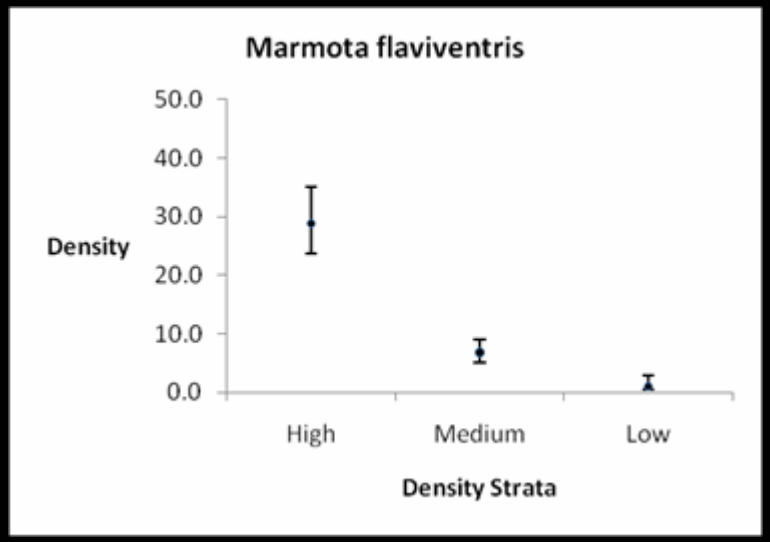


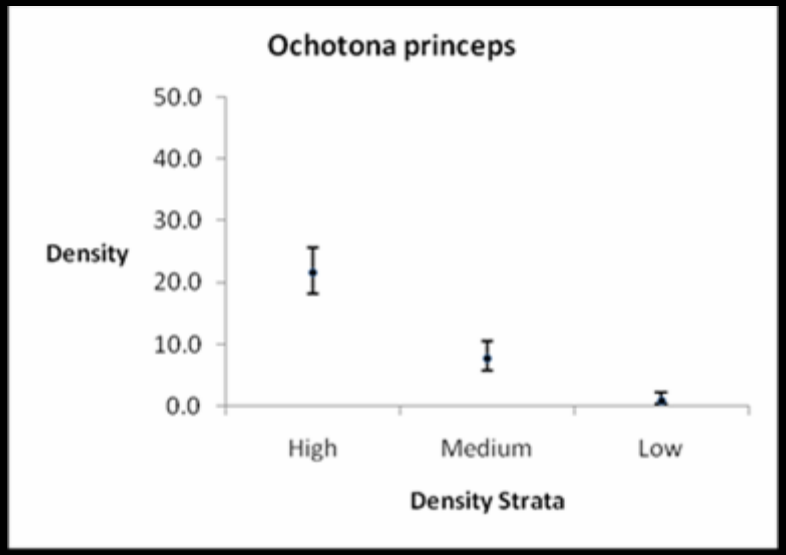


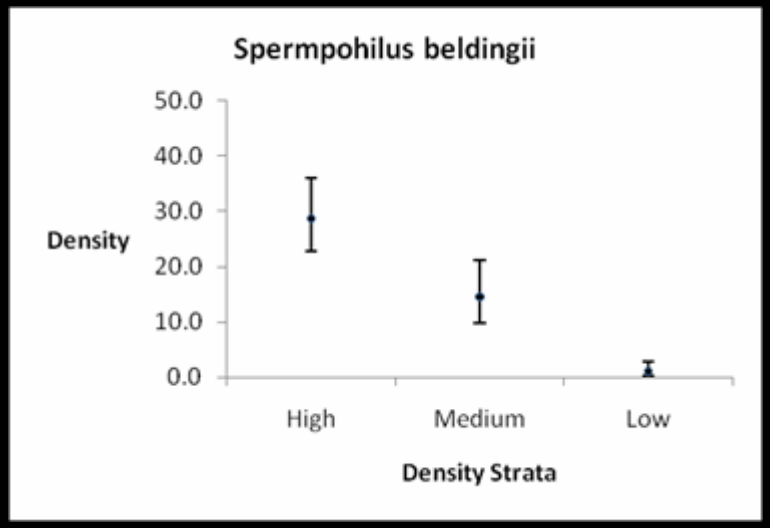


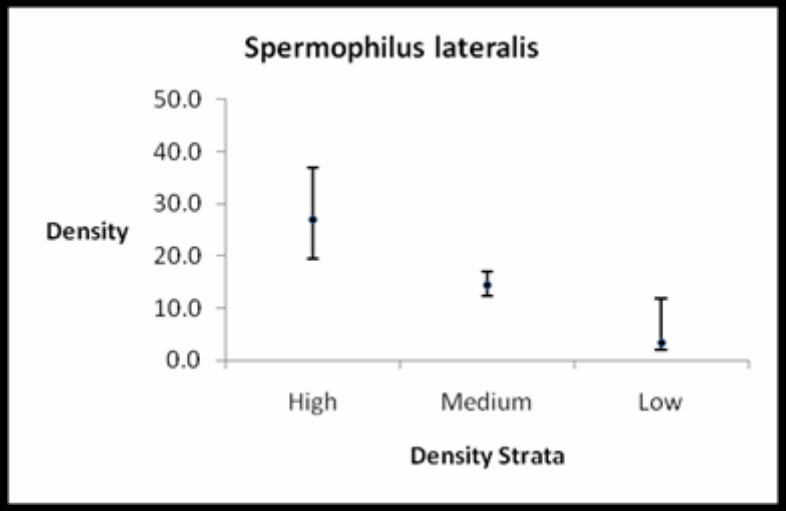


Density Estimates By Abundance Strata

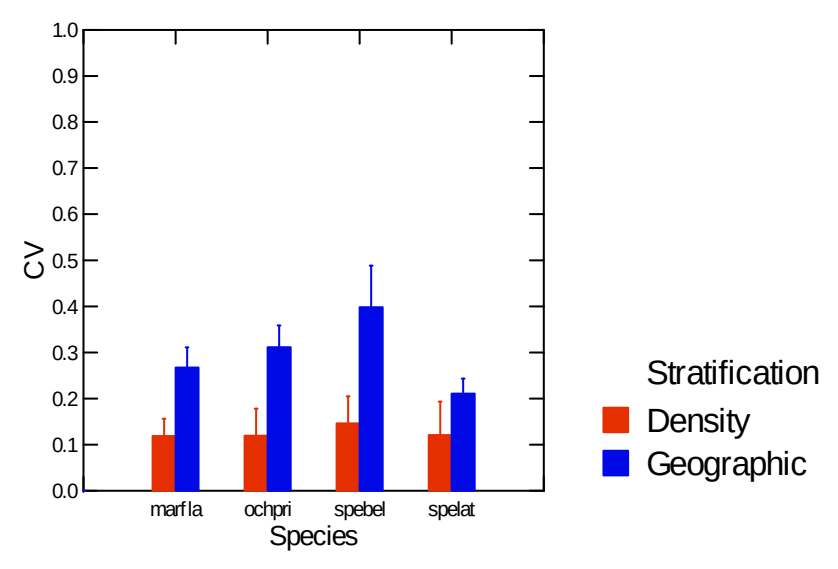


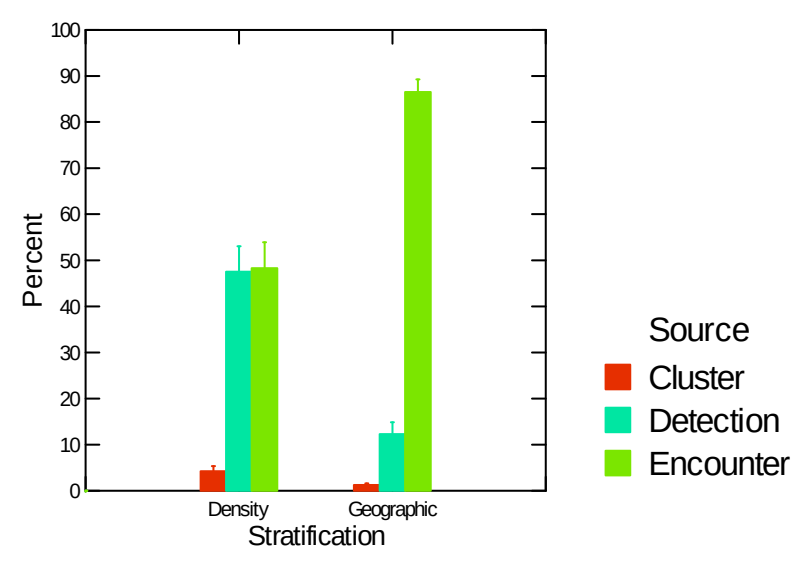




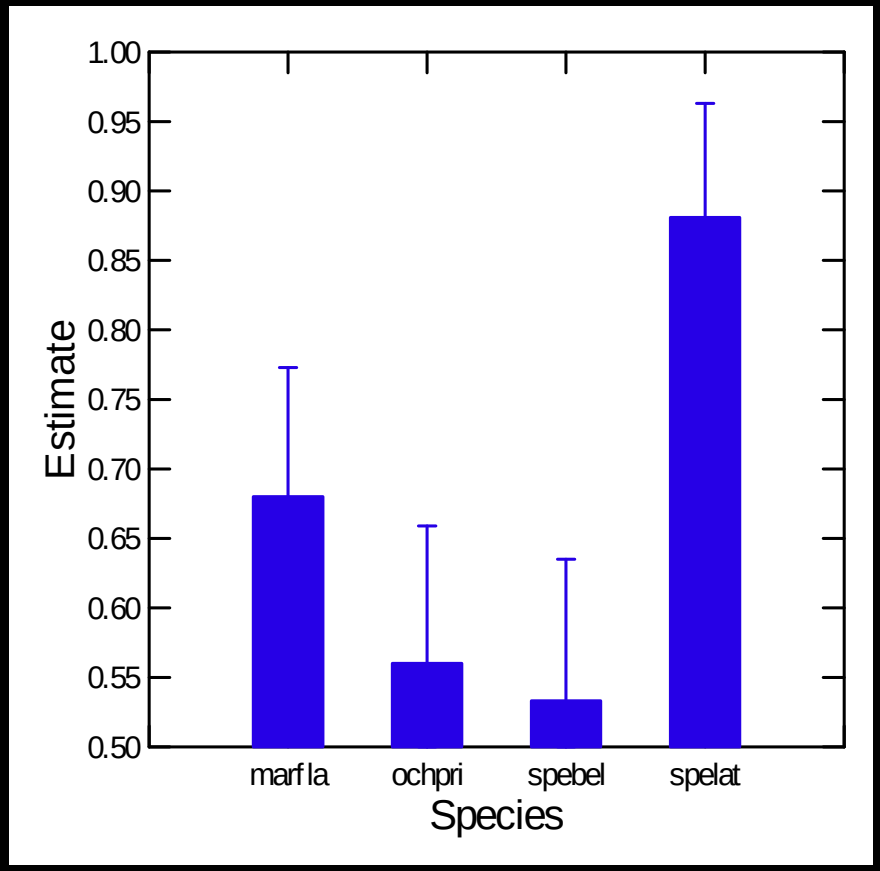


Sources Of Variation For Density Estimates



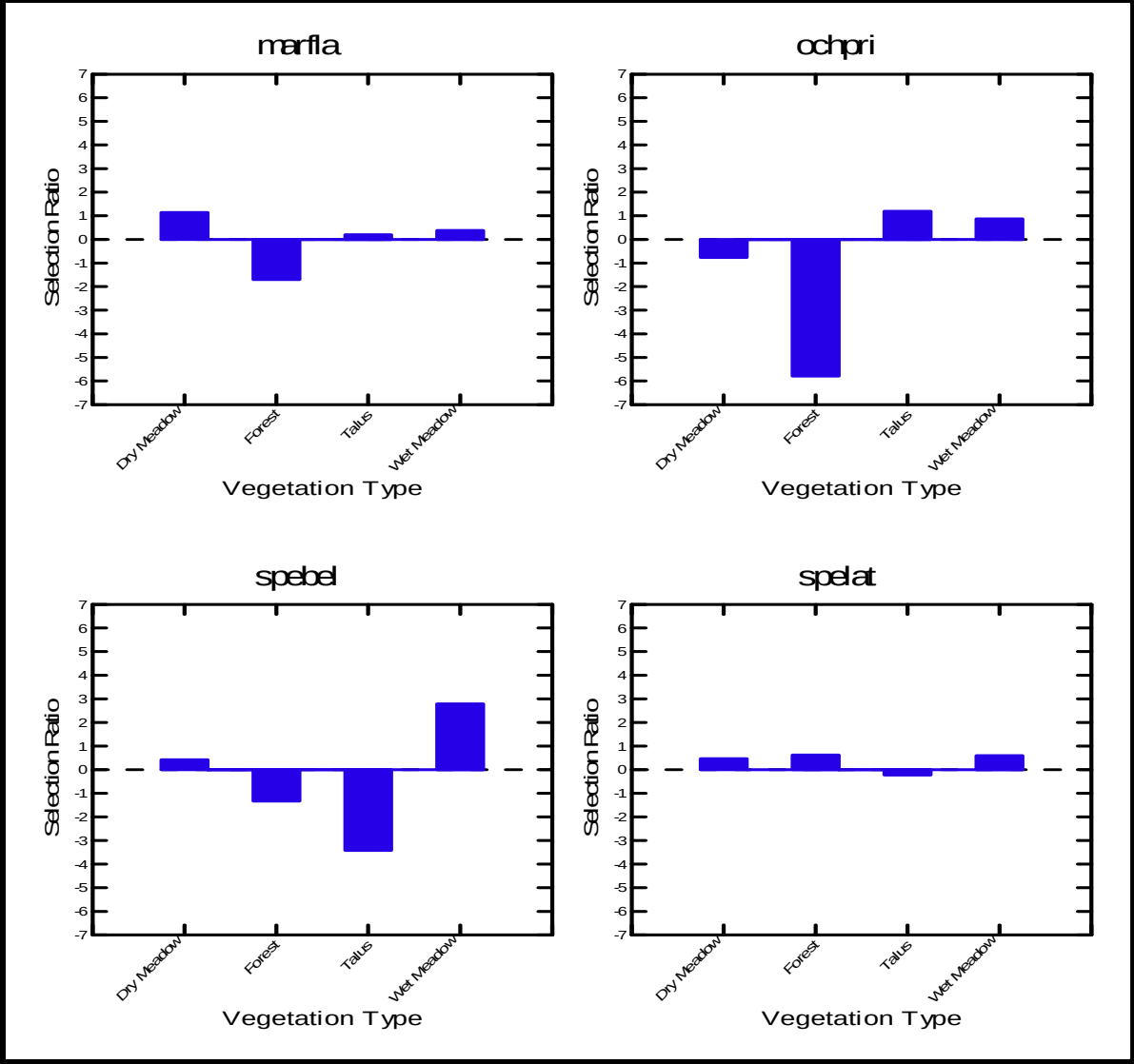


Occupancy



Best fit models for yellow-bellied marmot, American pika, and Belding's ground squirrel indicated two strata. Best fit model for golden-mantled ground squirrel indicated one strata.

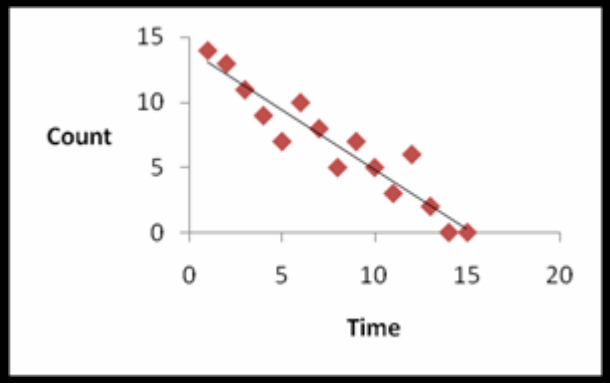
Vegetation Use Relative To Availability

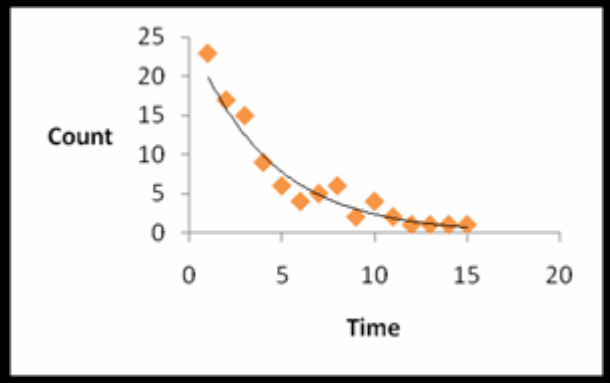


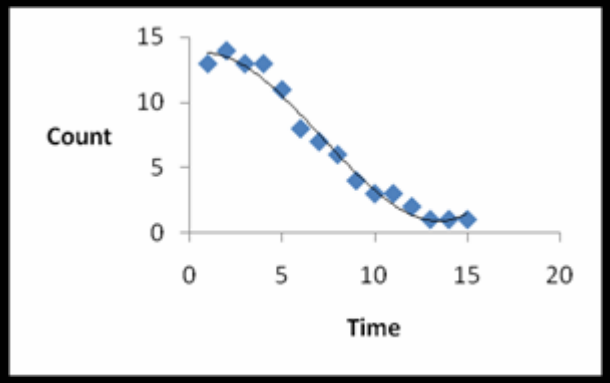
Interpreting Results

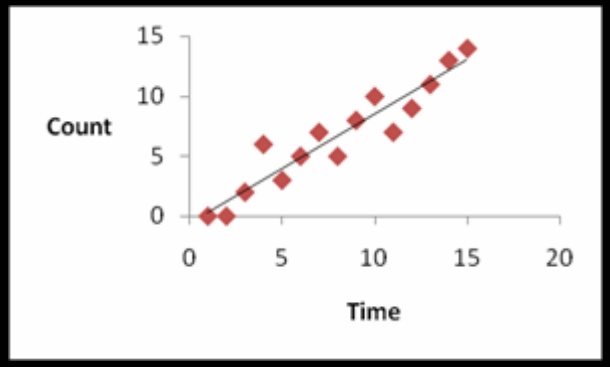
- Density, occupancy and vegetation use data indicate critical importance of habitat structure
- Species-distribution models must include variables other than climate (or its surrogate)
- Indirect effects of climatic shifts may be more important than direct effects
- Expect spatially and temporally variable patterns of persistence among and within species

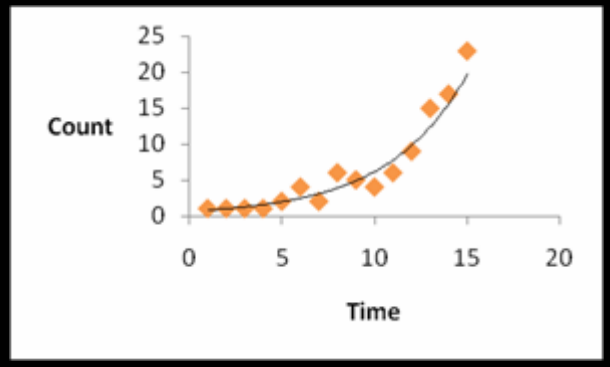
Modeling Persistence

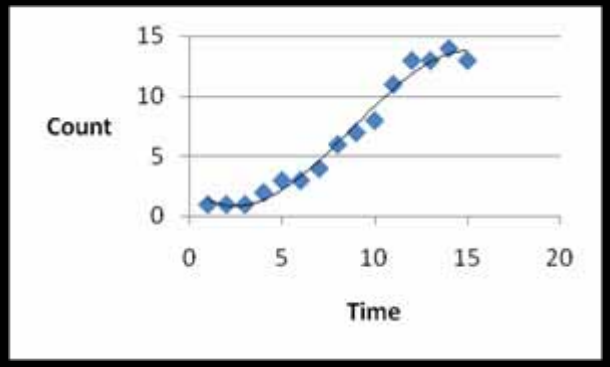












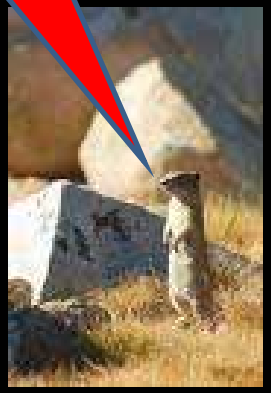
Singing A Different Tune

(…and I am still apologizing to REM)

It's the end of the world as we know it (in places)…

It's the end of the world as we know it (but I have a great tan)…

It's the end of the world as we know it (but I was gonna move anyway)…



And I feel fine (most of the time)!