Demographic Perspectives on Long-term Ecological Research in Organismal Biology

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- Improved assessment of community dynamics: closed population models
- Better metrics of habitat use: occupancy models
- Synthetic population modeling: seasonal components of demography, climate change

Demographic Parameters of Interest

Community

Transition rates: extirpation, species turnover

Abundance: species richness

Population

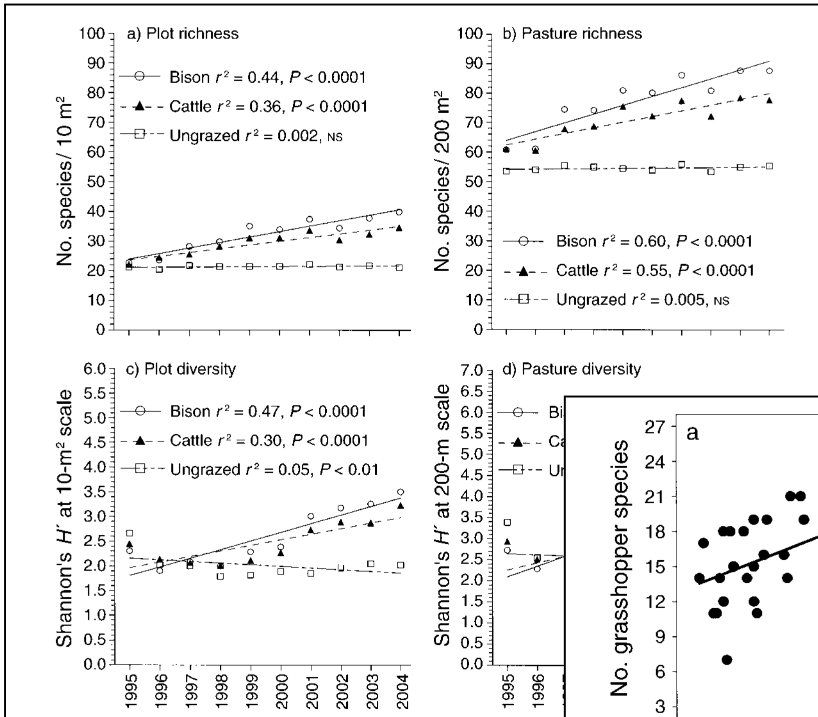
Transition rates: apparent survival, probability of changing states, recruitment, population growth

Abundance: number of individuals

Need to correct for probability of detection

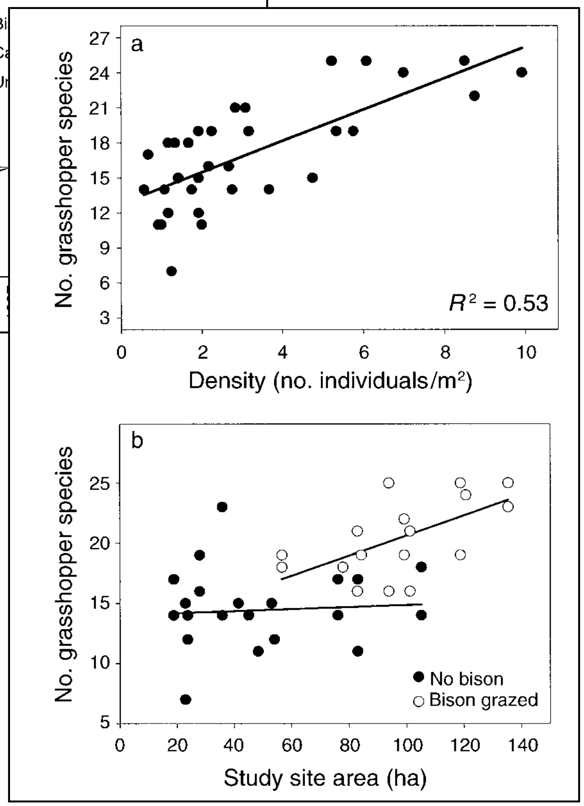
Mark-recapture analyses based on encounter histories for individuals or species

Sandercock 2006 *J. Wildl. Mgmt.*



Plants

Towne et al. 2005 *Ecol. Appl.*

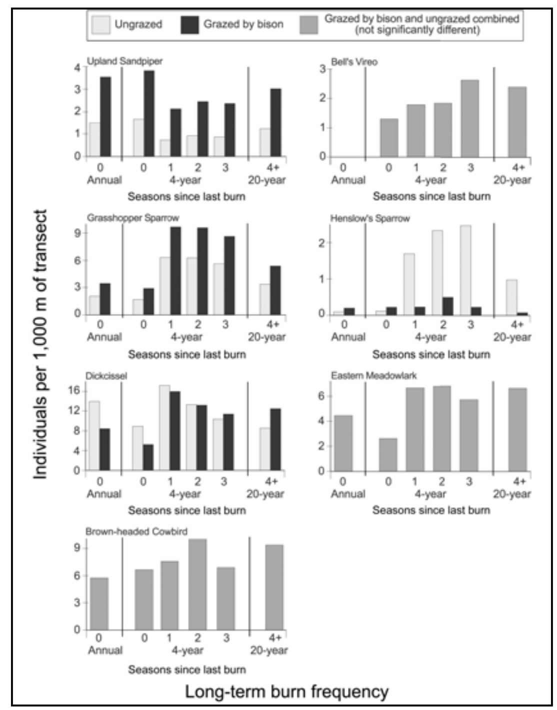


Grasshoppers

Joern 2006 *Ecology*

Birds

Powell 2006 *Auk*

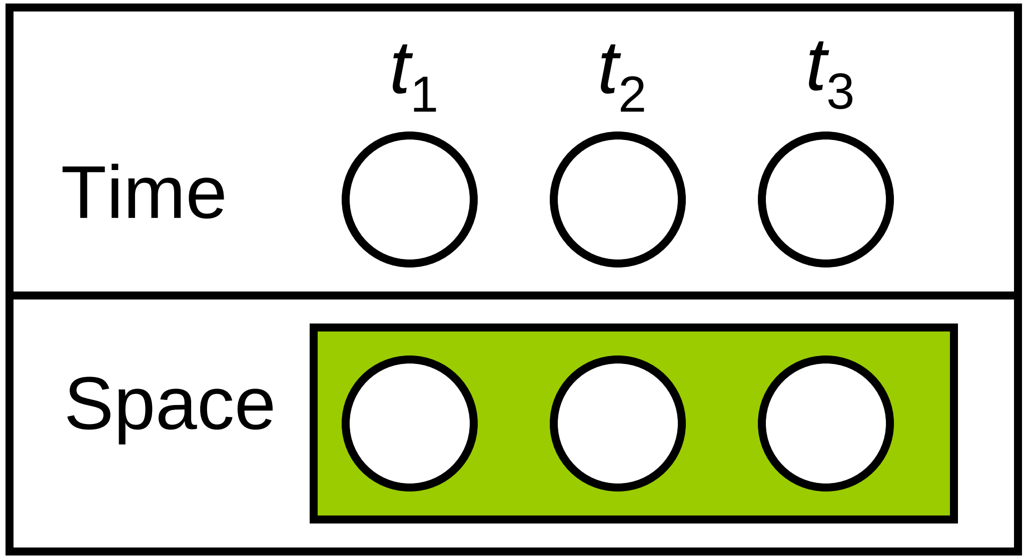


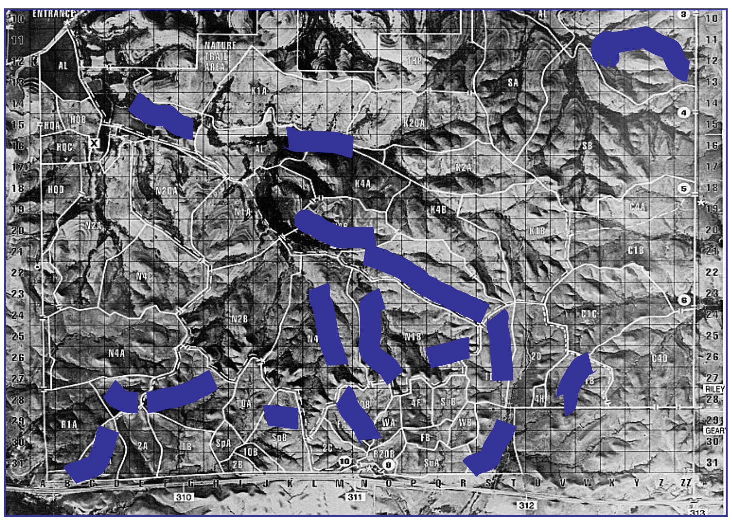
$$\hat{N} = C / \hat{p}$$

Species richness based on count data

Closed Population Models Estimate Abundance

$\hat{p}$ modeled as a function of: time, behavior, individual heterogeneity





LTER Repeated Sampling

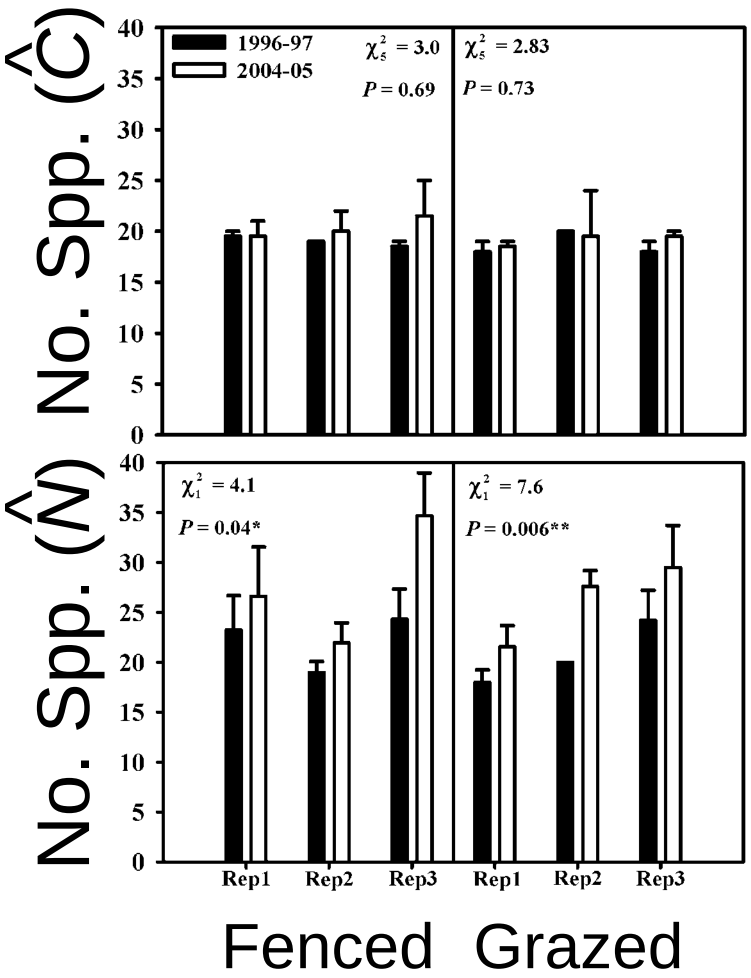
Plants: Yes, 5 plots/transect

Grasshoppers: Yes, 2 periods

Fish: No

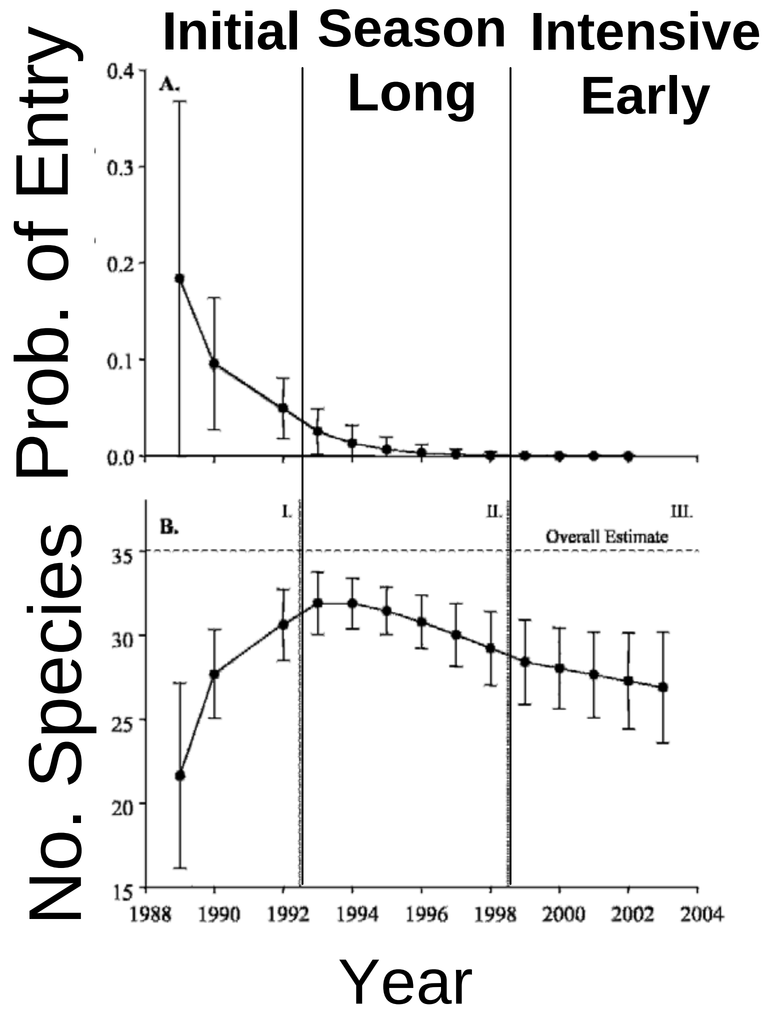
Birds: No

Avifauna



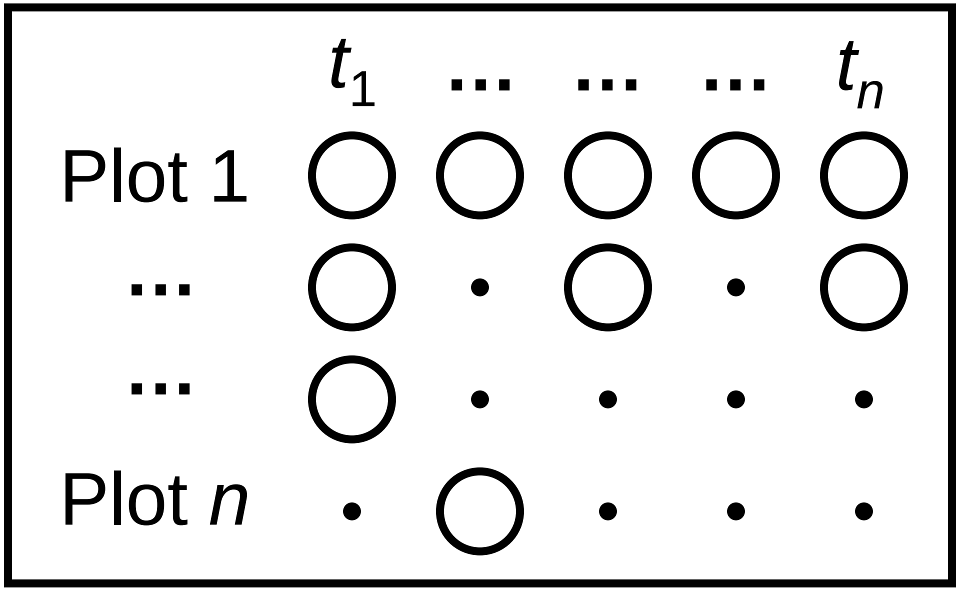
Johnson 2006 *MSc thesis*

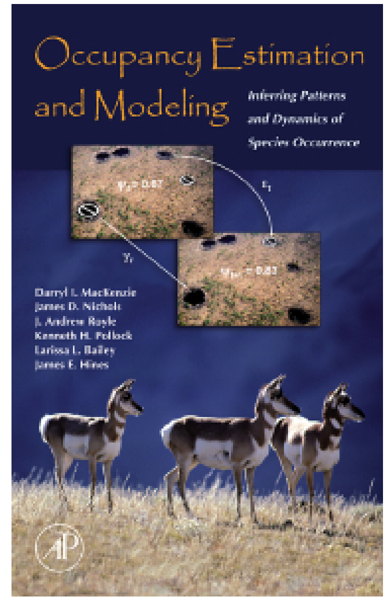
Herpetofauna



Wilgers et al. 2006 *Herpetologica*

Occupancy Instead of Abundance?





MacKenzie et al. 2005

Two Parameters

Occupancy (ψ) = probability that a species is present at a sampling site (or proportion of sites occupied)

Detection (*p*) = conditional probability that a species is detected at a site, given presence

Occupancy Models for Prairie Butterflies?

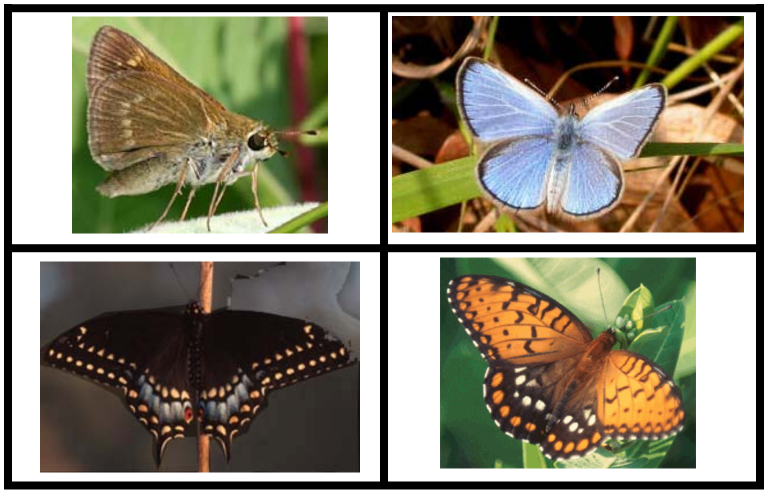
Occupancy

Lo ψ Hi ψ

Detection

Lo p

Hi p



Tips for study design

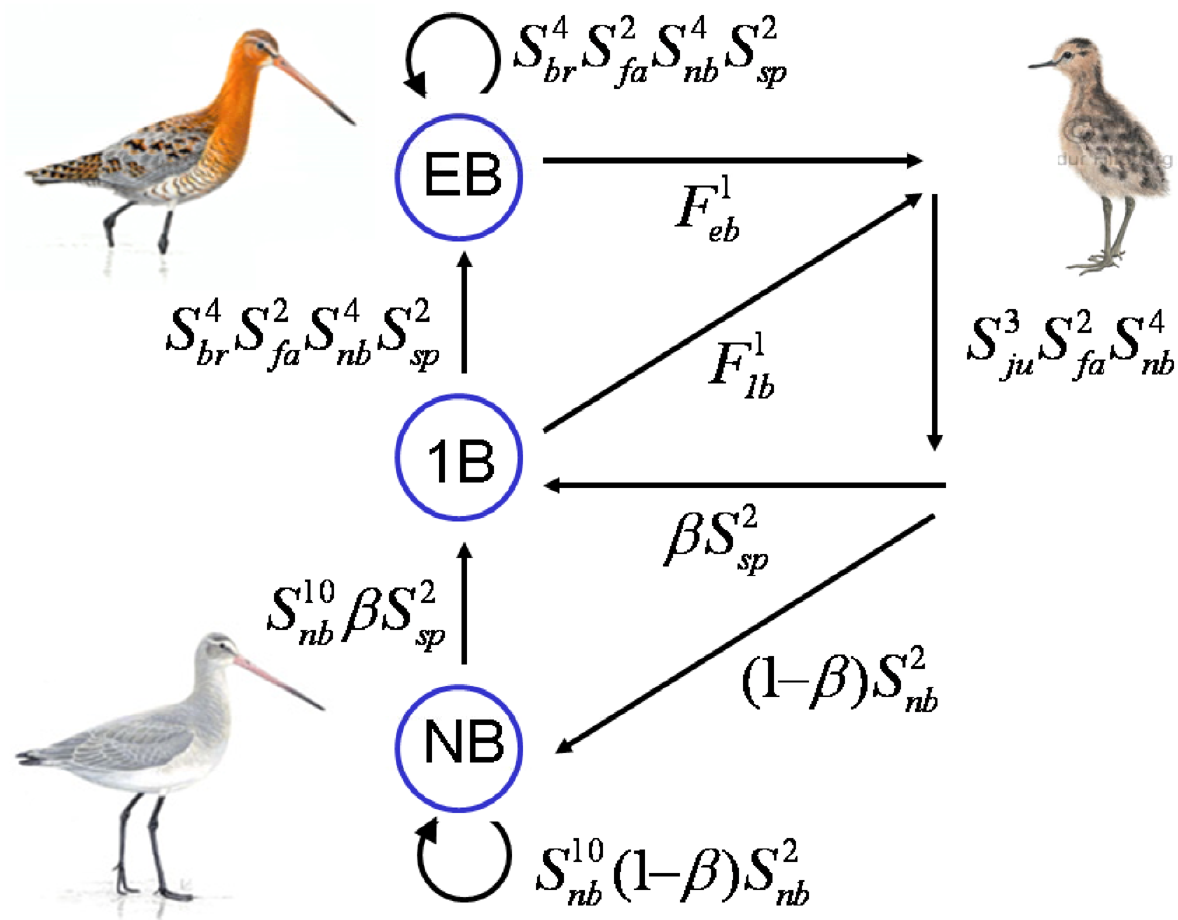
Sites must be selected at random

Rare species: More sites, fewer visits

Common species: Fewer sites, more visits

Model ψ and p versus environmental covariates

Stochastic Population Models



Seasonal demography of migratory birds

- Demographic tradeoffs vs. migration
- Population limitation and regulation
- Targeted conservation

Upland Sandpiper Demography

Clutch size
- 3.9, 3.8-4.0 (*n* = 158)

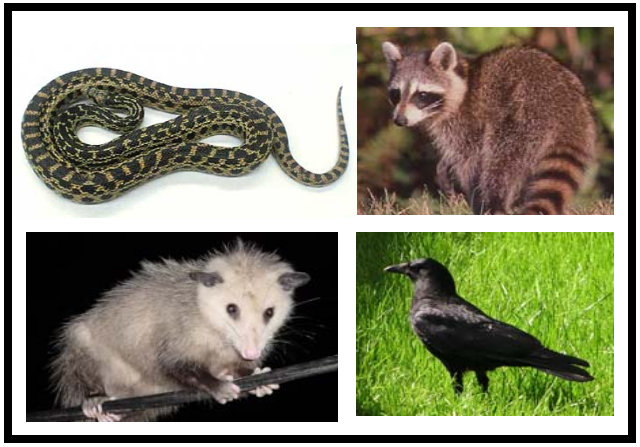
Prob. of renesting
- 0.22, 0.08-0.43 (*n* = 81)

Chicks/egg
- 0.86, 0.81-0.92 (*n* = 68)

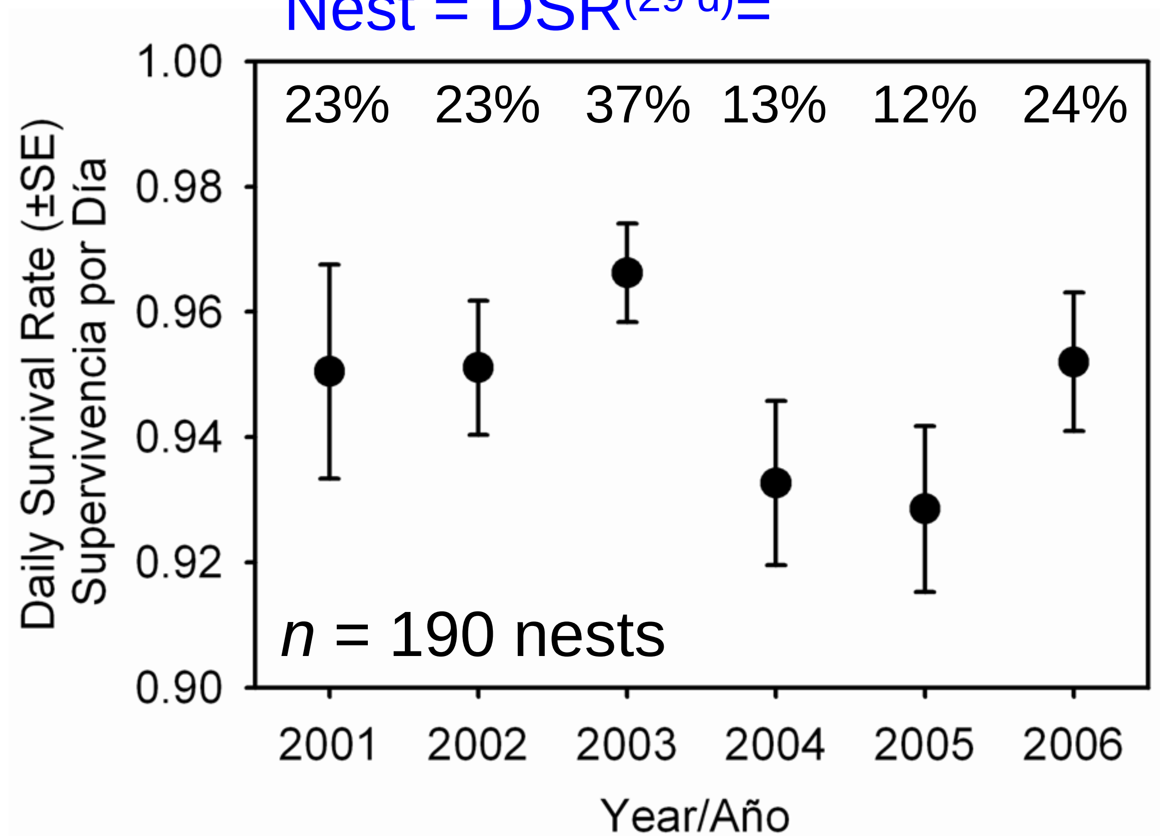
Sex ratio
- 0.48, 0.43-0.51 (*n* = 153)

Age at maturity
- 1-year

Survival of Nests

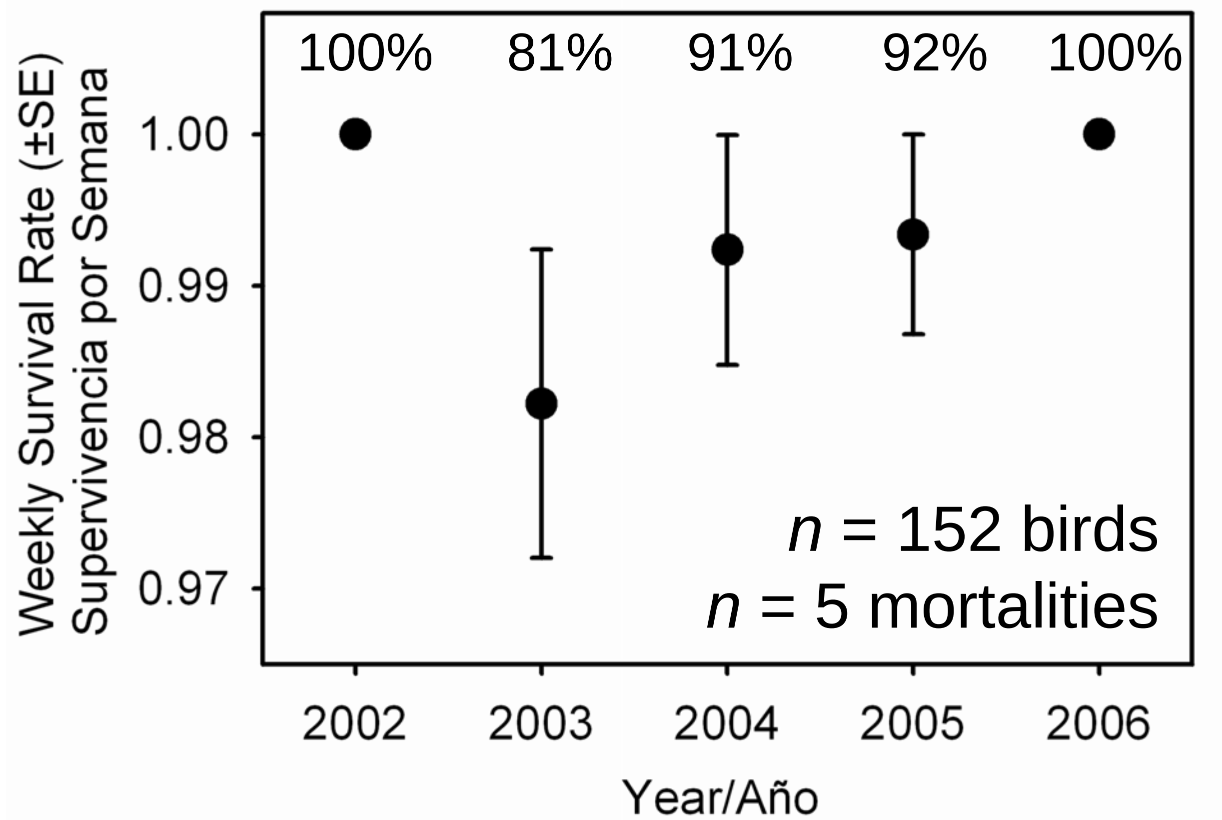


Nest = DSR$^{(29\ d)}$=



Summer Survival

$S_{sum} = WSR^{(12\ wk)} =$

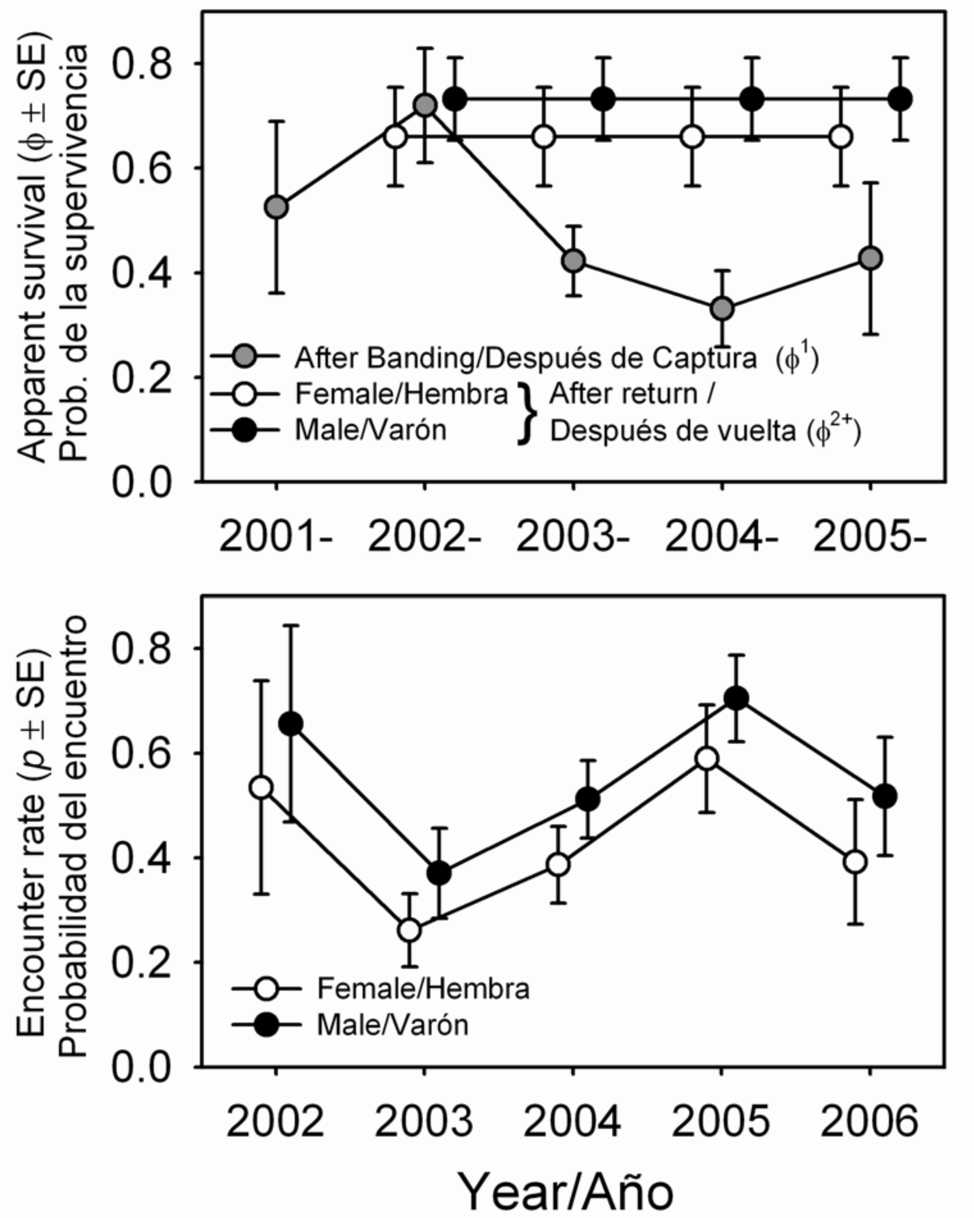


Mong and Sandercock 2006 *J. Wildl. Mgmt*

Annual Survival

n = 423 adults
minAIC: $\phi^1_t, \phi^{2+}_{sex}, p_{sex+t}$

- Prob. of detection low, varies with time and sex
- Effect of transients
- Annual survival of females = 0.66 ± 0.09SE



Synthesis

- Calculation of fecundity (female young per female)

$$\text{Rep} = [\text{Nest Survival} + ((1 - \text{Nest}) \times \text{Renest})] \times \text{Clutch size} \times \text{Chicks/egg} \times \text{Sex ratio}$$

- Calculation of survival during winter and migration

$$S_{win} = S_{ann} / S_{sum}$$

- Calculation of juvenile survival

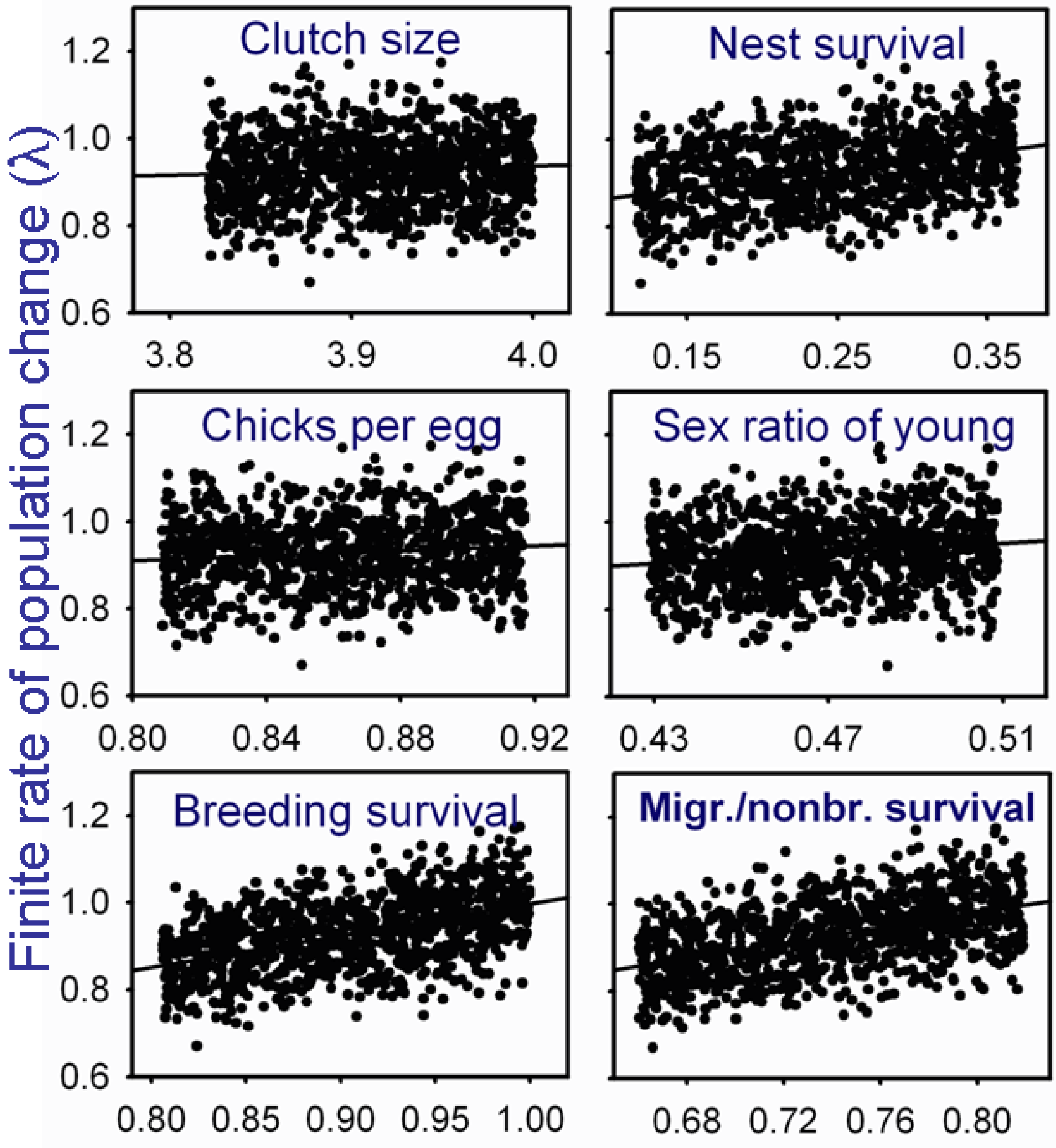
$$S_{juv} = S_{win} \times 50\%$$

- Calculation of finite rate of population change (λ)

$$\lambda = (\text{Rep} \times S_{juv}) + (S_{sum} \times S_{win})$$

- Life-stage simulation analyses (LSA), bootstrapping, based on uniform probability distributions

Life-stage Simulation Analysis



	$S_{ju} = wS_{mi/nb}$		
	0.25	**0.50**	0.75
Clutch	0.00	**0.00**	0.01
Nest	0.09	**0.14**	0.19
Renest	0.08	**0.29**	0.39
Chick	0.00	**0.01**	0.01
Sex	0.02	**0.03**	0.04
S_{br}	0.43	**0.25**	0.15
$S_{mi/nb}$	0.41	**0.24**	0.15

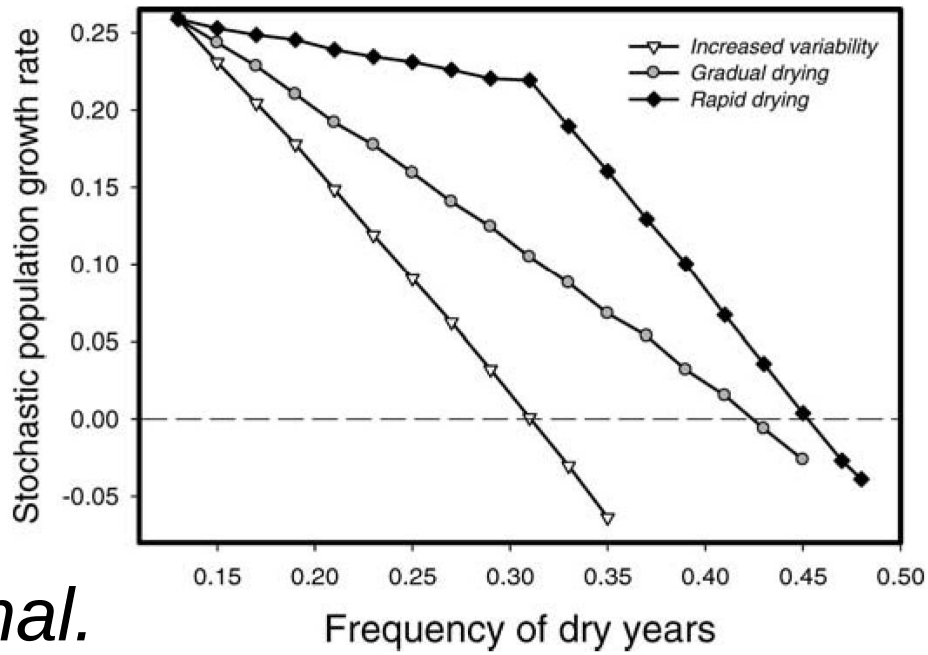
Stochastic Population Models

30-yr precipitation data
3-yr field study: dry (z = -1.13), normal (+0.19), wet (+0.93)
Fecundity, growth, survival for stage-structured model

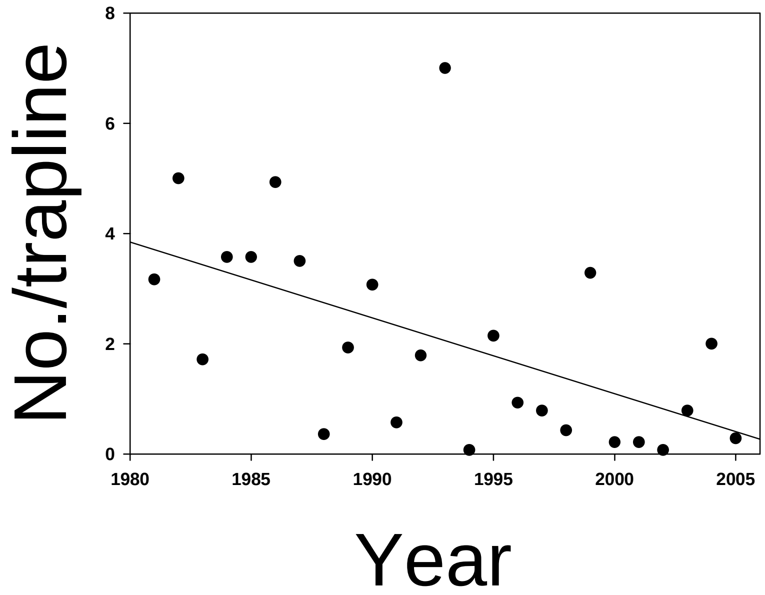
$$\begin{pmatrix} 0 & 0 & F_3 & F_4 \\ G_{12} & S_{22} & 0 & 0 \\ 0 & G_{23} & S_{33} & 0 \\ 0 & 0 & G_{34} & S_{44} \end{pmatrix}$$

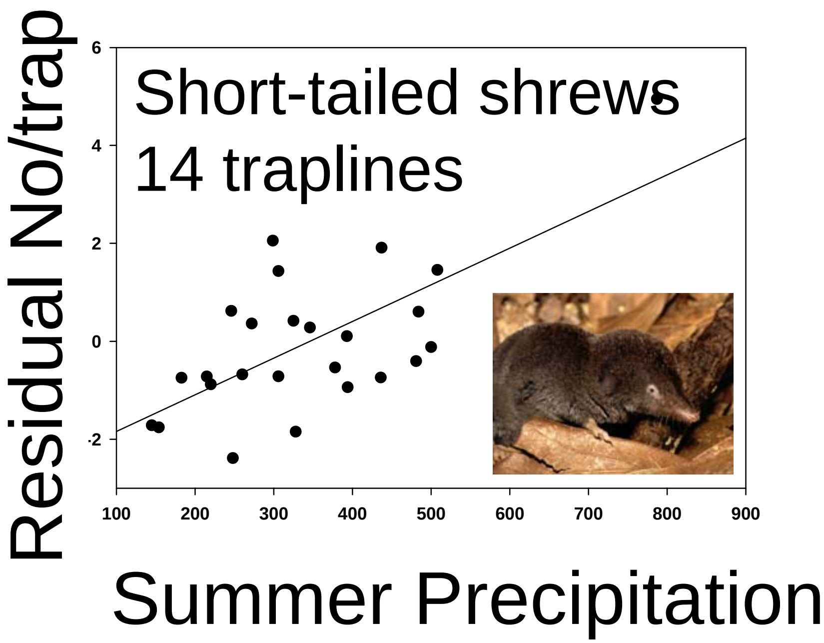
50-yr projections
Independent, identical distributed series (*iid*)

Reed et al. 2007 *J. Mammal.*



Count-based Population Viability Analyses





- Possible to conduct stochastic modeling with unstructured models if population change linked to environmental conditions

Summary

- Benefits of demographic perspective: estimates with less bias and greater precision, improvements in sampling efficiency, greater synthesis
- Opportunities for novel improvements without new experiments, reversal treatments, exclosures.