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Site Occupancy (Models)

AND

Detectability

Broad Applications for Science, Monitoring and the Sampling of Populations

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Basics of Sampling Populations

- Why: Goals/objectives of the data collection
- What: - Abundance or population size
  - Proportion of area occupied
  - Species richness
- How: 2 sources of error
  - Detection probability
  - Spatial variation

Site Occupancy

- **MacKenzie et al. 2002 (based on capture-recapture theory)**
- **Arbitrarily defined spatial unit or discrete naturally occurring sample units.**
- **Estimate what fraction of sites (or area) is occupied by a species knowing that species is not always detected, even when present.**
- **Model Parameters**
  - p_{ij} probability of detecting the species in site *i* at time *j*, given species is present
  - Ψ_i probability site 'i' is occupied

Site Occupancy

- MacKenzie et al. 2002 (based on capture-recapture theory)
- Key design issues: Replication and Spatial Variation
  - Temporal: repeat visits to sample units.
  - Spatial Variation: probabilistic selection of 'sites' within area of interest.

Site Occupancy: Uses

- Surveys of geographic range
- Habitat relationships
- Incidence functions and metapopulations

Single point in time

- Observed colonization and extinction
- Extensive monitoring programs: 'trends' or changes in occupancy over time and space

Change over time

Allocation of effort (within season)

- **Under a simple design there is an optimal number of repeat surveys per unit (K)**
- **The optimal number depends upon values for "ψ" and "p"**
- **Does not depend upon number of sites or total number of surveys**
- **Reasonably robust to effect of cost**
- **Charts exist**

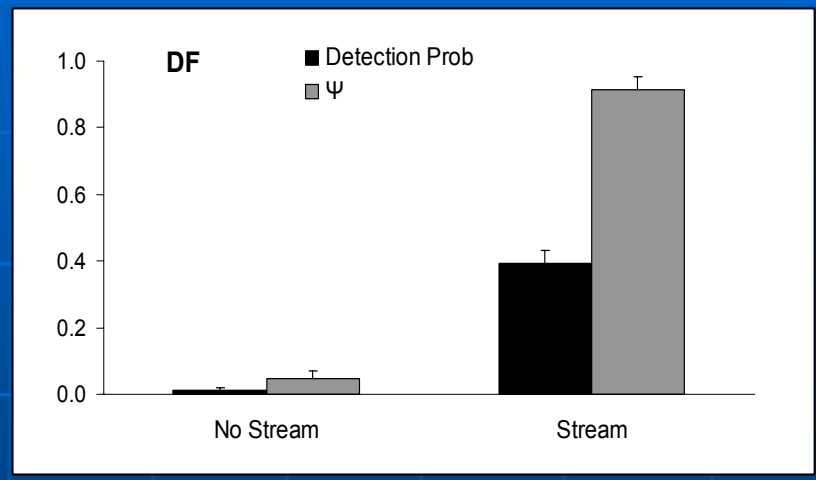
(MacKenzie and Royle 2005)

Model Assumptions

- Sites closed to changes in occupancy between sampling occasions
- No heterogeneity that cannot be explained by covariates (J.A. Royle papers)
- Detection process is independent at each site

Estimating Site Occupancy and Vital Rates for Terrestrial Salamanders

Larissa Bailey
USGS Patuxent Wildlife Research Center &
USGS Cooperative Research Unit
North Carolina State University



Experimental Analysis of Detection Probabilities on Avian Point Counts

Ted Simons, Ken Pollock, Mat Alldredge, Krishna Pacifici
USGS Cooperative Fish and Wildlife Research Unit & Depts.
Zoology, Biomathematics, and Statistics - NC State University

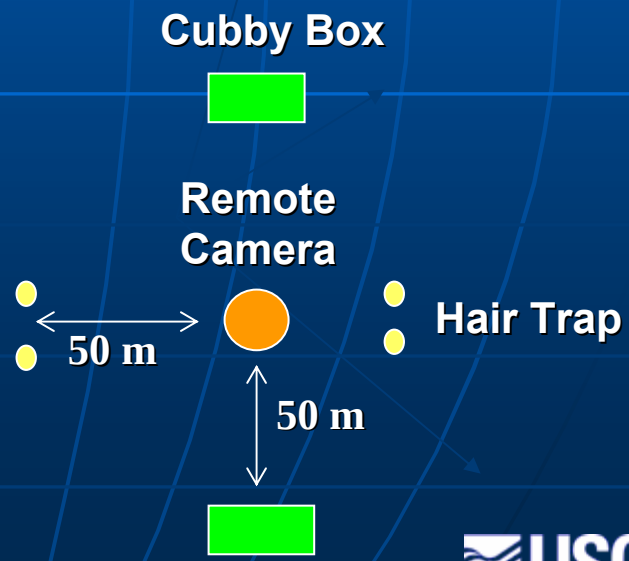
Rigorous estimates of diversity and abundance are essential for monitoring the status and trends of populations.....

Understanding Detection Probabilities is Key to Improving the Quality of Bird Census Data

Monitoring Medium-Sized Mammals

&

Estimation of Occupancy and Detection Probabilities



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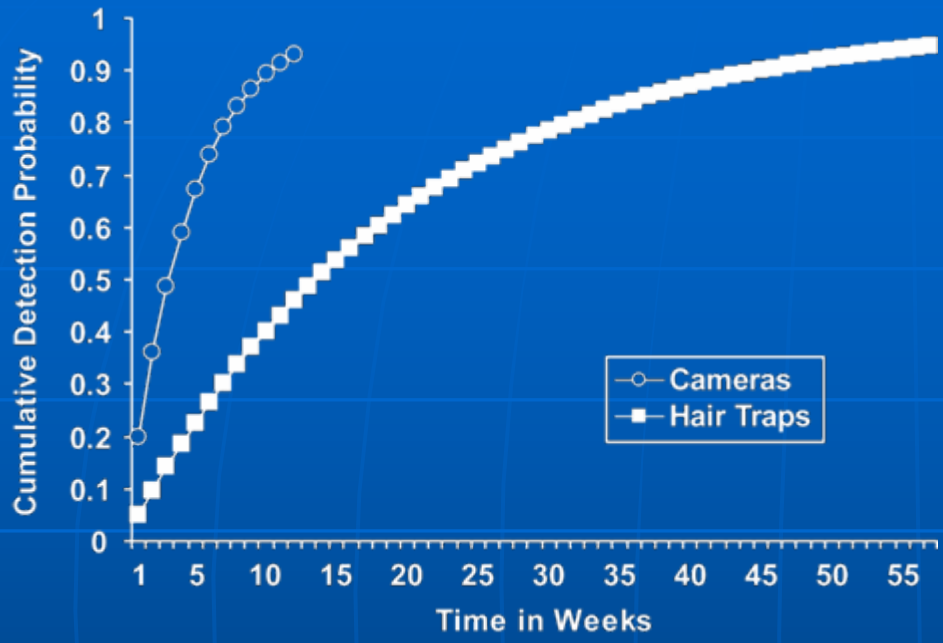
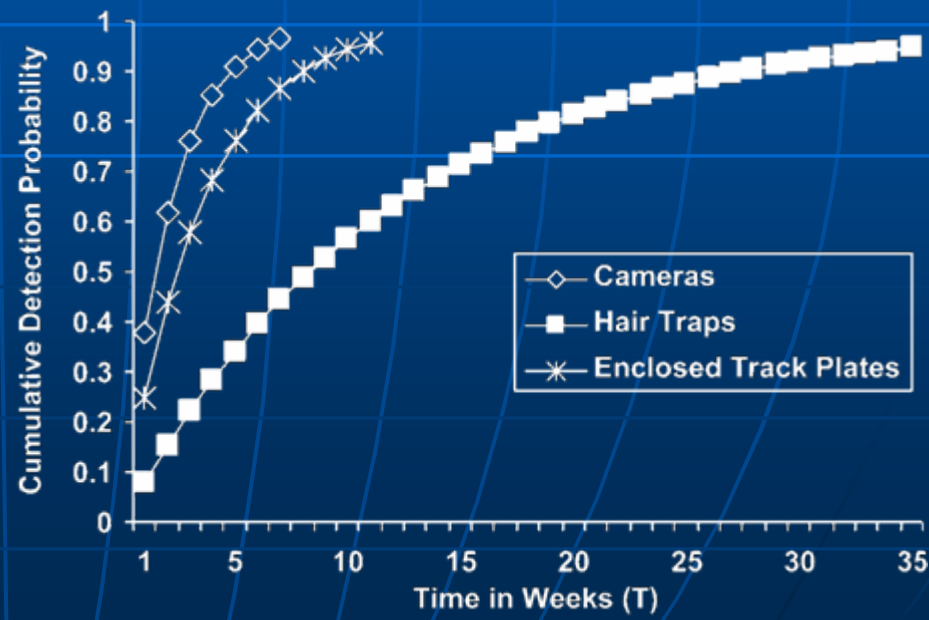

Cumulative Detection Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 5 10 15 20 25 30 35 40 45 50 55
Time in Weeks
Cameras
Hair Traps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0.4
0.3
0.2
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0
1 5 10 15 20 25 30 35
Time in Weeks (T)
Cameras
Hair Traps
Enclosed Track Plates

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Effects of Habit Fragmentation and Landscape Context on Medium-Sized Mammals in Northeastern National Parks

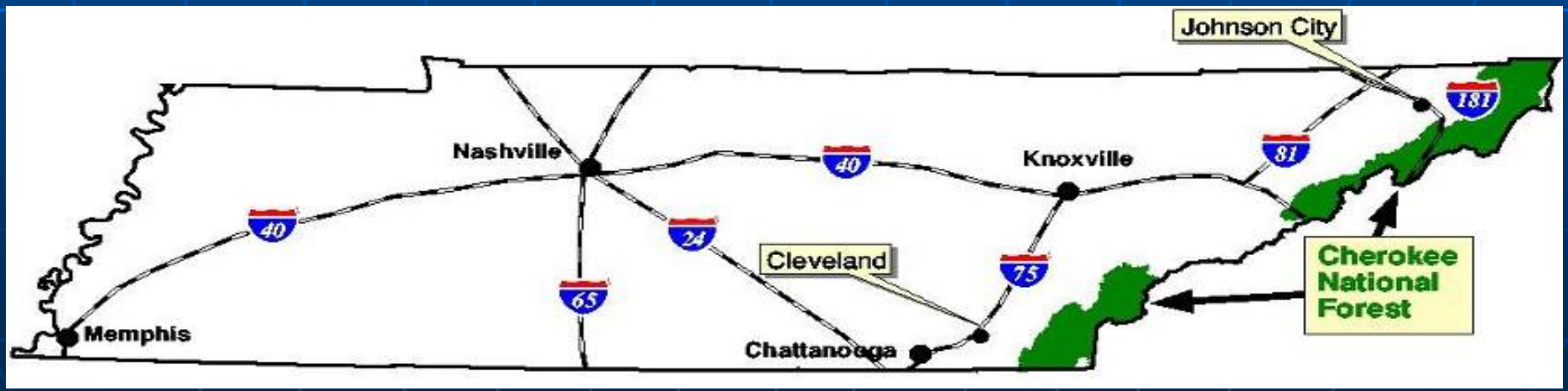
Neil W. Talancy

URI/CESU

Results – Fisher

Multi-scale Models	AIC_c	ΔAIC_c	AIC_c Weights
Ψ (Overstory Density$^+$, Latitude$^+$) P (Forest 2600$^+$)	209.84	0	0.54
Ψ (Latitude$^+$) P (Forest 2600$^+$)	212.6	2.75	0.13
Ψ (Overstory Density$^+$, DBH$^+$, Latitude$^+$) P (Forest 2600$^+$)	212.74	2.89	0.12
Ψ (Overstory Density$^+$, DBH$^+$) P (Forest 2600$^+$)	214.41	4.56	0.05
Ψ (.) P (.)	229.66	19.81	0

Cherokee National Forest



Science-Based Monitoring of Nutria

- Remote cameras, track devices, audio callbacks
- Prevent re-invasion and destruction of coastal marshes
- Focus future eradication efforts

Model Deficiencies

- Some study designs restrict types of models
- Modeling co-occurrence causes parameters to increase exponentially
- Situations in which presence and detection probabilities are heterogeneous

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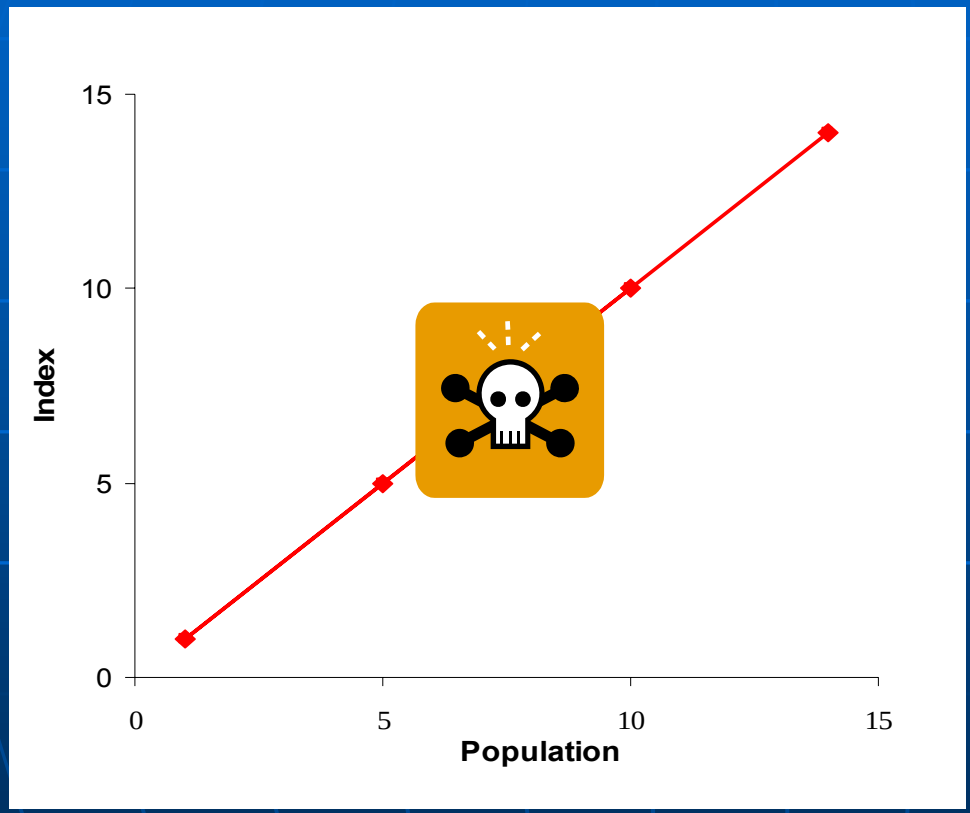
Beyond Wildlife and Ecology…

- From Occupancy Models to Stars
  Phil Whiting, Lucent, Bell Labs
- Multi-site, multi-barrier, multi-occupancy models for the electrical behavior of single filing channels like those of gramicidin
- Storage complexity of memory structure on computers
- IBM (detectability of errors in software programs)
- U.S. Census Bureau

Most studies simply count # sites with occurrence ⇨ count is used to estimate occupancy *without detectability*



Assume that all species are detected, $p = 1$

Detection probability is the same for species, times, locations, or sampling methods

Detection rates vary over time and space, which can cause bias in population estimates that use index values.

Serious about estimating *change* in the populations YOU sample?

Whether occupancy, species richness, or abundance

there is a fundamental need to

Incorporate Detectability!

“Change is indeed painful, yet ever needful”

Thomas Carlyle (Scottish Essayist, 1795-1881, addressing issues of social and scientific change)