

# New Approaches for Estimating the Spatial Distribution and Abundance of a Species

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# New Approaches are Widely Applicable

- Many large monitoring programs rely on abundance estimates, and sometimes the target species is either rare or hard to detect
  - Wading birds
  - Snail kites
  - Alligators
  - Burmese pythons
- Abundance is a common benchmark for assessing restoration efforts
  - thresholds (e.g., minimum population size)
  - trends (e.g., rate of increase or decline)

- ① New approaches (developed during last decade)
  - sampling populations
  - estimating abundance
  - estimating and predicting spatial distribution
- ② Practical implications for updating conventional sampling methods
- ③ Relevance to monitoring programs
  - Example for this presentation: Cape Sable seaside sparrow
- ④ Quantitative assistance from U.S. Geological Survey

# Why new approaches?

## Commonly expressed views

- “I already know how to sample!”
- “I know detection errors occur, but mark-recapture is not feasible.”
- “Site-specific abundances are too low for fancy sampling protocols.”
- “I don’t have the time. It’s too much work.”

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## Essential components of new approaches to monitoring

- ① Sampling design - ensures locations are representative of population
- ② Sampling protocol - provides information about both abundance *and* detection probability
- ③ Hierarchical analysis of data
  - distinct – but connected – models of counts and abundances
  - estimate abundance and detection at sample locations
  - estimate effects of spatially varying covariates (e.g., habitat) on abundance

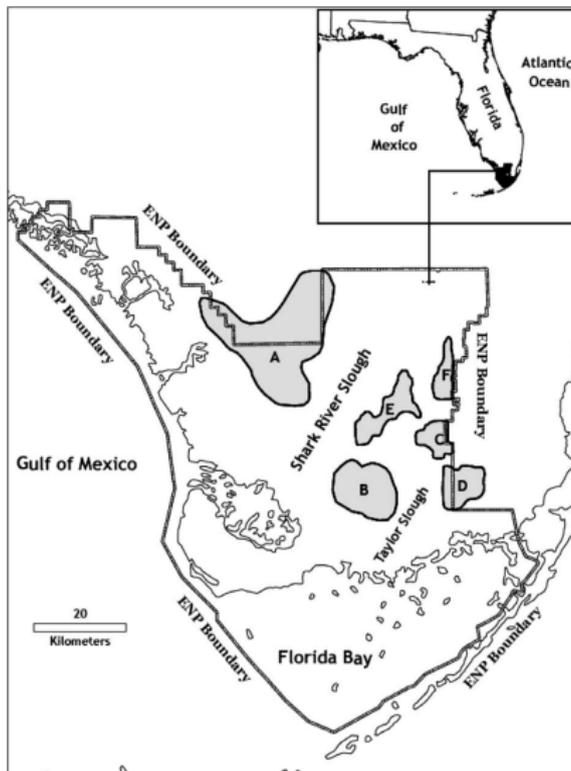
# Cape Sable Seaside Sparrows (Walters et al., 2000)



Sparrow in seasonally flooded prairie

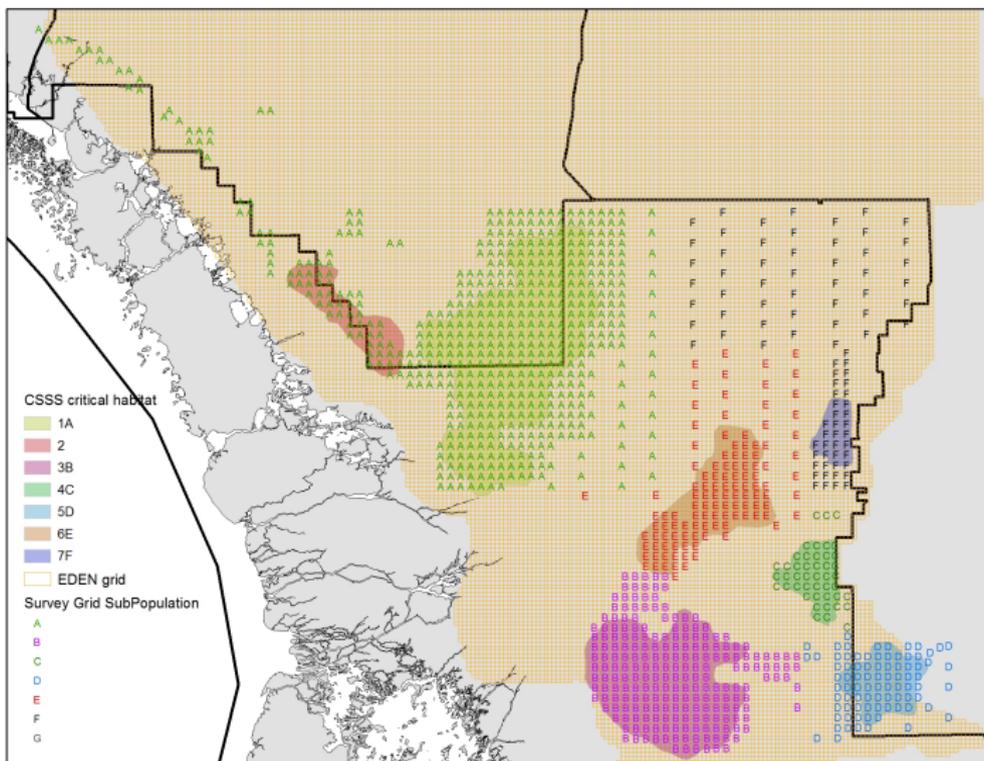
## Important factors?

- West: increased hydroperiod and frequency of floods
- East: increased frequency of fire-prone conditions



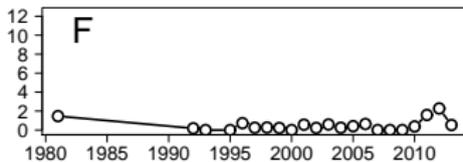
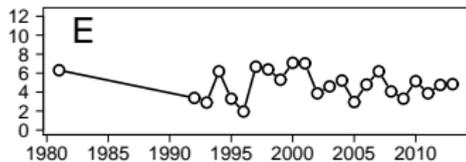
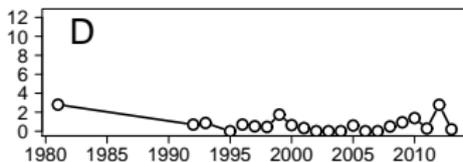
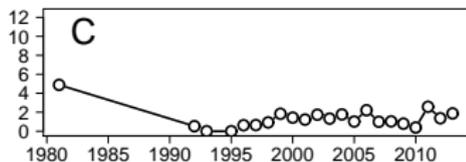
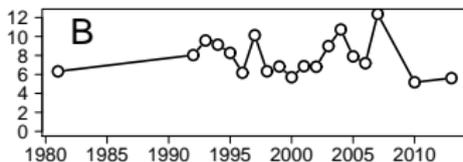
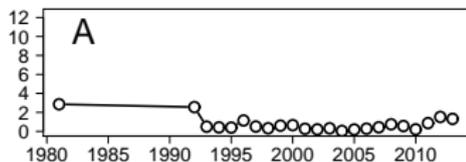
(Cassey et al., 2007)

# Existing Sample Frame for Sparrow Surveys



# Observed Density of Sparrows in Surveys

Average no. birds / square km



Year

# Current Estimation of Sparrow Abundance

## Bass and Kushlan's (1982) estimator

$$\begin{aligned} \textit{Abundance} &= \textit{Count} \times \frac{A_{\textit{quadrat}}}{A_{\textit{survey}}} \times 2 \\ &= \textit{Count} \times \frac{1}{\pi 0.2^2} \times 2 \\ &\doteq \textit{Count} \times 16 \end{aligned}$$

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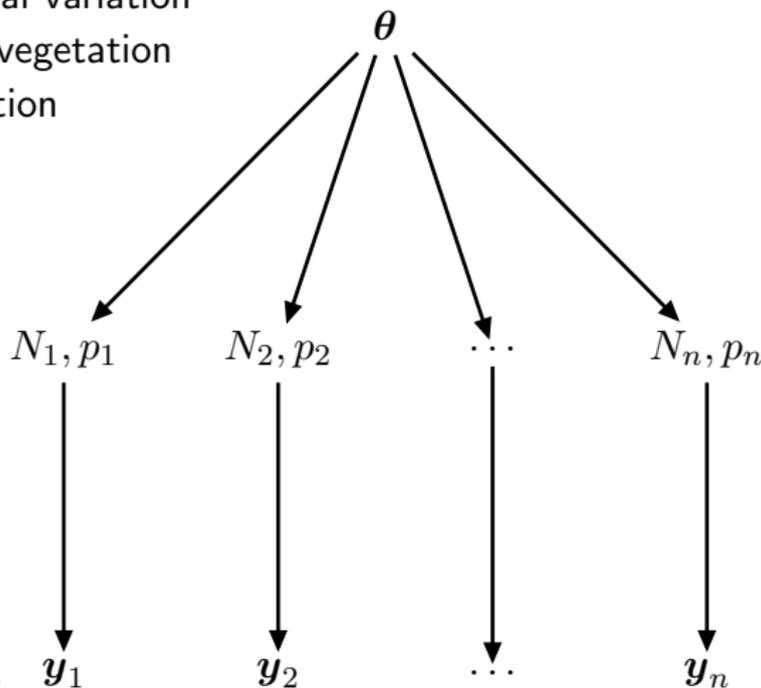
## Limitations

- implies no errors in detection
- fails to account for spatial and temporal differences in detectability
- does not specify effects of habitat on abundance
- uncertainty of estimator is not specified

# Hierarchical Analysis of Simulated Sparrow Data

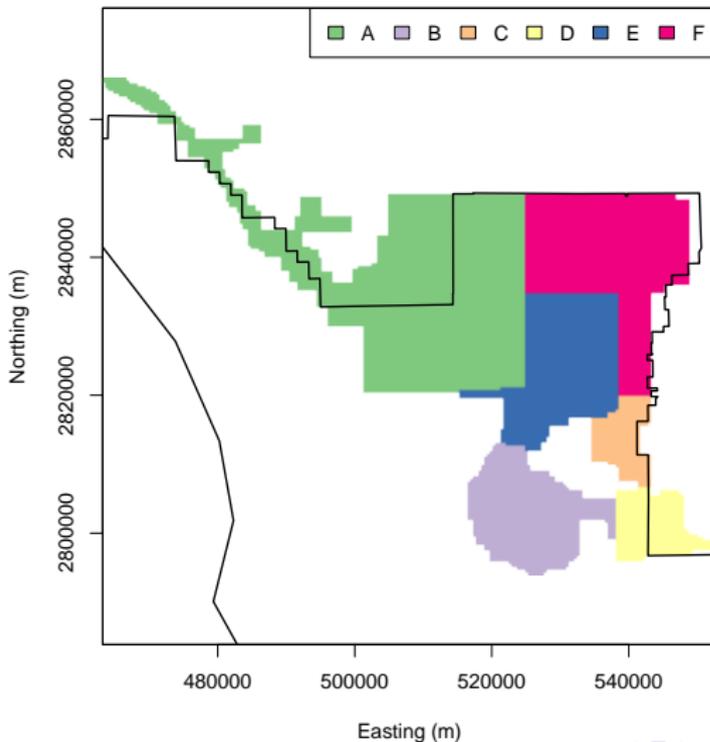
Effects of spatial variation  
in water level, vegetation  
and subpopulation

Abundance  
& detection

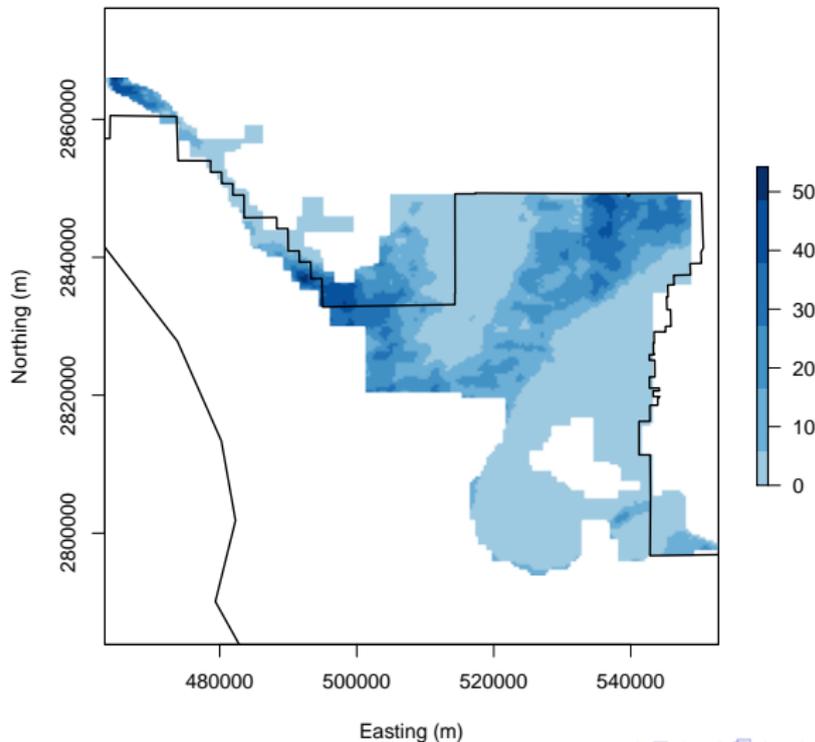


Dbl-obs counts

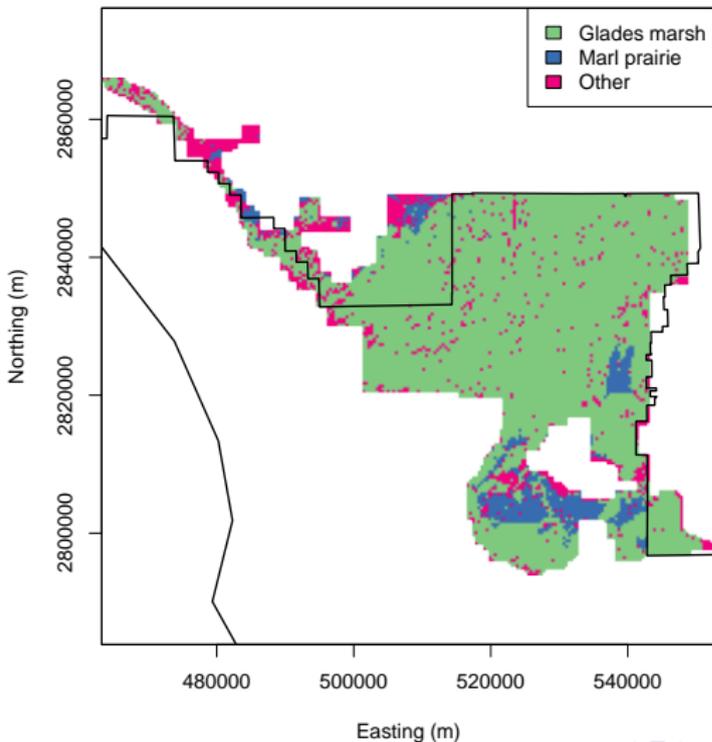
# Sample Frame for Hypothetical Sparrow Surveys



## Water Level (cm)



## Vegetation categories



# Hypothetical Double-observer Surveys of Sparrows

## ① Sampling design

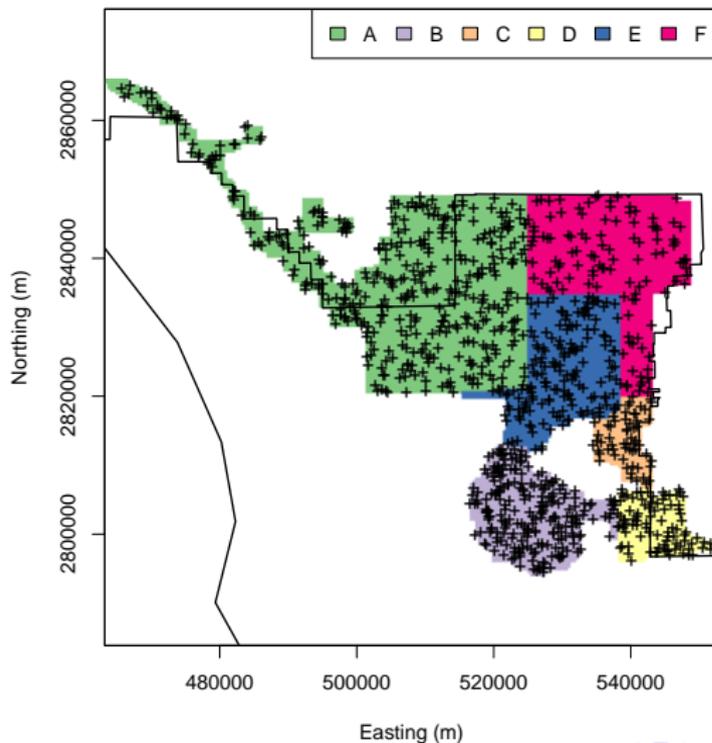
- sample unit = 200 meter  $\times$  200 meter plot
- stratified random sampling  
(A=2%, B=4%, C=3%, D=3%, E=2%, F=1%)

## ② Sampling protocol - independent surveys of 2 observers

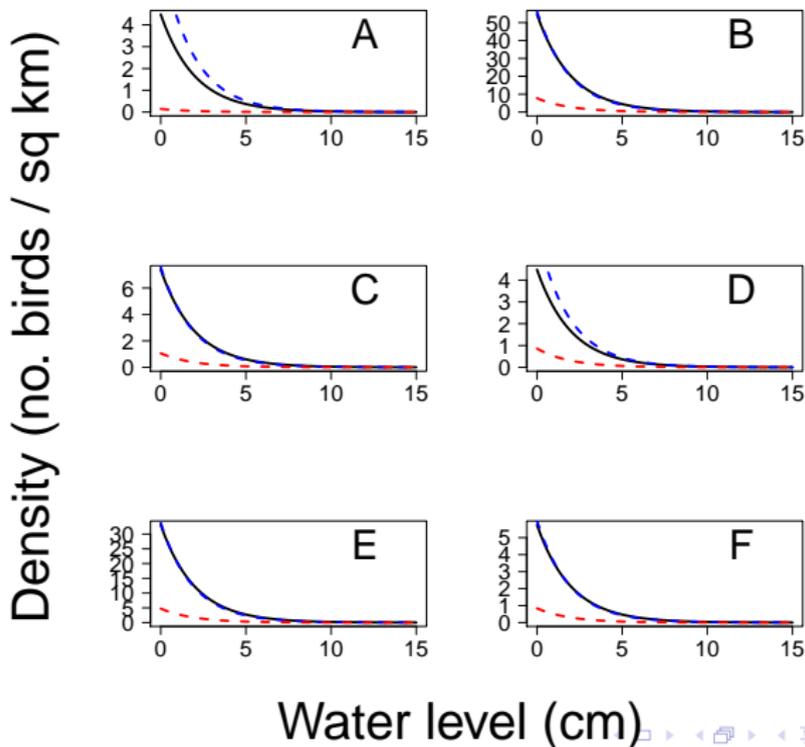
## ③ Assumptions of hierarchical model:

- Abundance  $\rightarrow$  subpopulation, water level
- Detection probability  $\rightarrow$  observer, vegetation category
- Counts  $\rightarrow$  plot-level abundance and detection probability

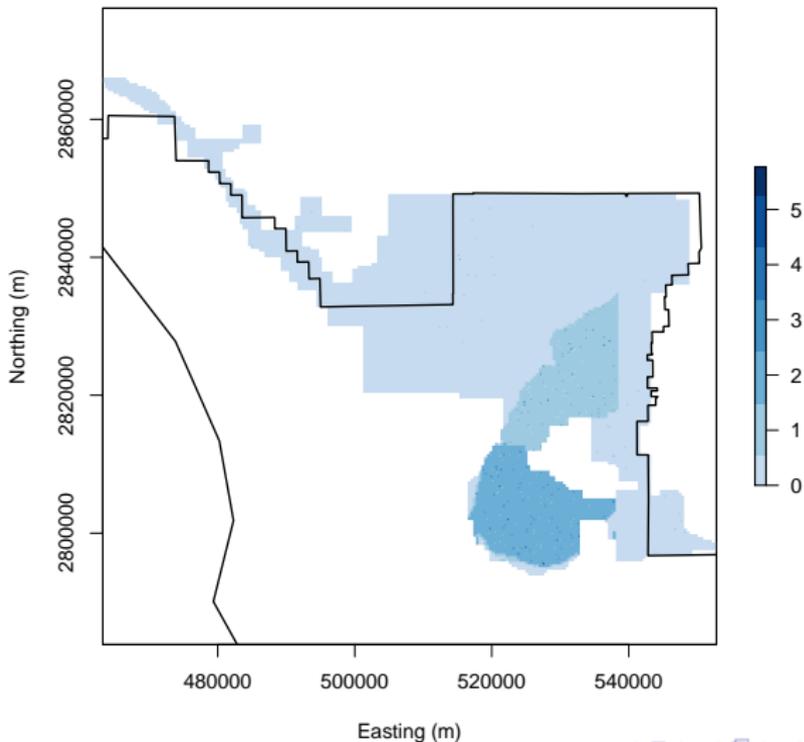
# Hypothetical Sample Locations



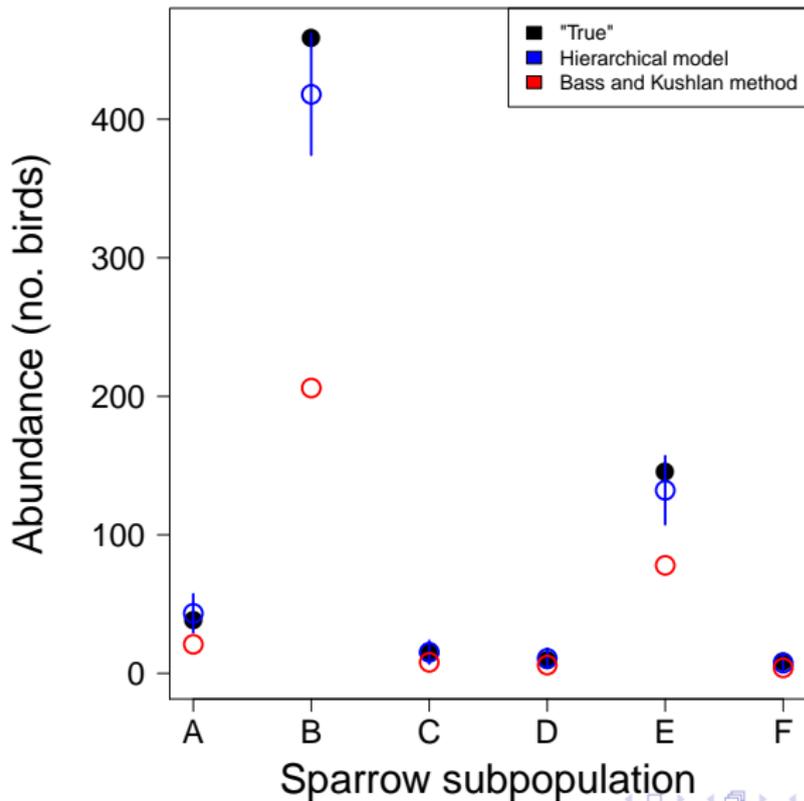
# "True" and Estimated Sparrow Densities (solid="true"; blue dash = hier model; red dash=conv model)



# Predicted Distribution of Sparrow Abundance (200 m × 200 m sample units)



# "True" and Estimated Abundance of Sparrows in Sample



# Recommendations for Sparrow Monitoring Program

- 1 Current point-count surveys of sparrows can be improved
- 2 A small change in sampling protocol (double observers) provides big benefits:
  - Estimates of *true* abundance of sparrows
  - Estimates of effects of water level on sparrow abundance
  - Uncertainty of estimates is quantified
- 3 Potential alternatives to double-observer sampling of sparrows include:
  - removal sampling (using “virtual” removals)
  - distance sampling
  - repeated point-count sampling (involves greater effort and risk)

# Hierarchical Modeling Has Been Applied to Many Species

## Examples

- Aerial surveys of **manatees**\*
- Double-observer surveys of **crocodiles**
- Removal surveys of stream **fishes**\* and **salamanders**
- Capture-recapture surveys of **birds**
- Point-count surveys of **alligators**\*, **birds**, **lizards**, **salamanders**

\* surveys in Florida

# How can USGS assist you?

- 1 Development of statistically rigorous monitoring programs
  - sampling design
  - sampling protocol
- 2 Analysis of data
  - develop hierarchical models of abundance that account for detection errors
  - use hierarchical models to analyze monitoring data
- 3 Instructional workshops
  - development of monitoring programs
  - statistical methods of data analysis

**Overall Benefit:** Improves your ability to assess impacts of restoration on rare or hard-to-detect species

# References I

- Bass, O. L. and Kushlan, J. A. (1982). Status of the Cape Sable seaside sparrow. South Florida Research Center Report T-672, National Park Service, Homestead, Florida.
- Cassey, P., Lockwood, J. L., and Fenn, K. H. (2007). Using long-term occupancy information to inform the management of Cape Sable seaside sparrows in the Everglades. *Biological Conservation*, 139:139–149.
- Walters, J. R., Beissinger, S. R., Fitzpatrick, J. W., Greenberg, R., Nichols, J. D., Pulliam, H. R., and Winkler, D. W. (2000). The AOU conservation committee review of the biology, status, and management of Cape Sable seaside sparrows: final report. *Auk*, 117:1093–1115.