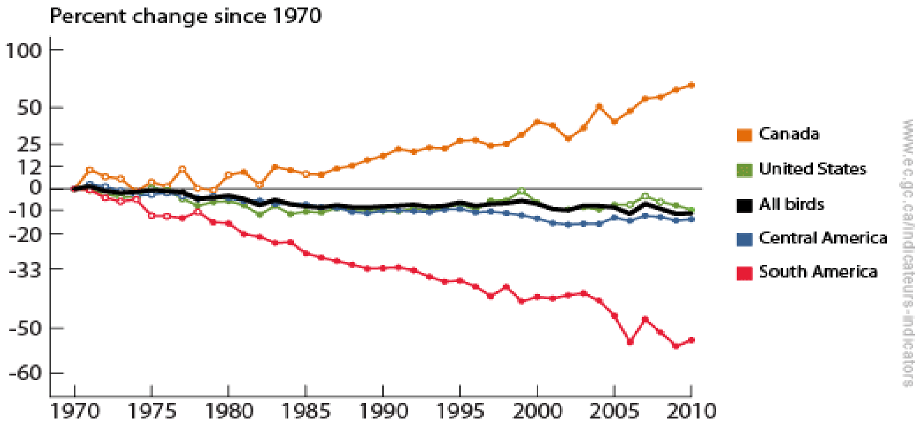
Analysis of demographic data

SSA 200

Estimating population vital rates

- Can use counts to model change in population size and the effect of covariates
- Intrinsic population characteristics govern population dynamics
- Stressors and threats often act directly on these rates
- This can help guide conservation actions to where it will be the most helpful and examine effects of potential management actions



Change in population size = births + immigration - deaths - emigration

Fecundity/Recruitment

- Nest/den monitoring
- Reproductive success/failure
- Number of offspring produced
- Age ratios

Survival

Apparent survival

- **Individual capture-mark-recapture**
- **Radio telemetry**

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Demographic data types

- Many different types, depends on ecology/life history of species of interest
  - Number of broods/litters per season
  - Breeding site fidelity
  - Etc.

Data types
Number of offspring per female
Ratio of young to adults (or size classes)
Nest/den success or failure
Number of young returning next year
Individual mark-recapture/resight
Radio telemetry
Others?

Demographic vital rate
Fecundity
Recruitment probability
Survival probability (seasonal or annual)
Breeding success probability

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Estimating fecundity

- From a population growth perspective, recruitment into breeding population is more important than fecundity
    - A product of many events: reproductive success, juvenile survival, site fidelity/dispersal
- Often easier to collect data on breeding success than recruitment
- Can estimate from individual-level data (nest/den success) or population-level data (ratio of young to adults)

GLMs to estimate fecundity

- Include ecological covariates to determine important drivers of breeding success
- Type of GLM depends on response variable
  - Number of offspring per female →
  - Successful breeding (yes/no) →

Estimating survival/mortality

- Radio telemetry → known fate models
  - Assume perfect detection of individuals

- Individual capture-mark-recapture → Cormack-Jolly-Seber (CJS) models
  - Data can come from a variety of sampling methods
    - Physical recapture (trapping array)
    - Photographic re-encounter (camera traps)
    - Re-sightings (field-readable tags, individually-identifiable marks)
    - Noninvasive genetic sampling (hair snares, scat collection)
  - Assume **imperfect detection** of individuals

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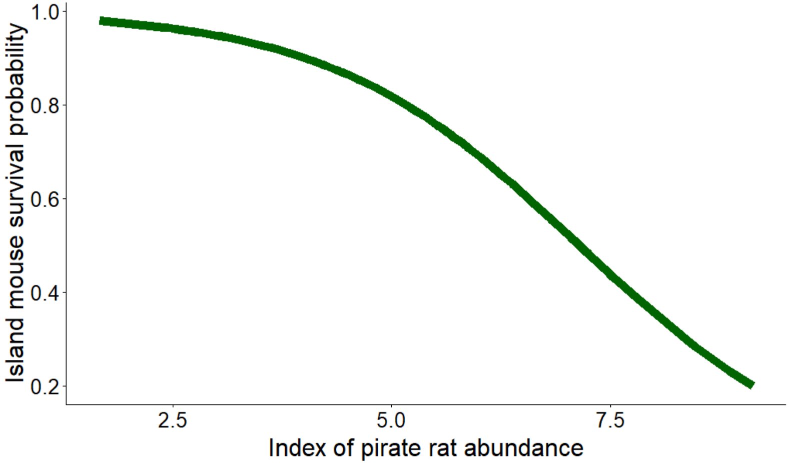
Linking survival probability to covariates

- **Logistic regression** is at the heart of survival estimation

$$logit(S) = \beta_0 + \beta_1 * Pirate\ rat\ abundance$$

- If $\beta_1 > 0$, then pirate rate abundance has a **positive** effect on survival
- If $\beta_1 < 0$, then pirate rate abundance has a **negative** effect on survival



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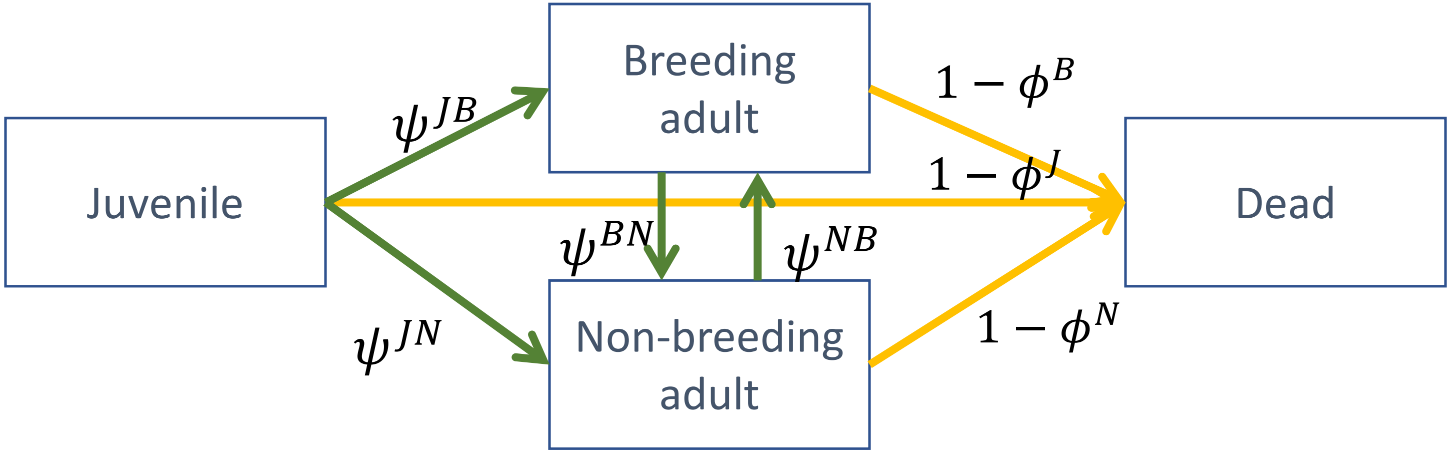
Multistate models

- Used to estimate transition probabilities among different physical sites or biological states
- Look similar to matrix models, but individuals can move back and forth between states
    - o Breeder/non-breeder status
    - o Disease status
    - o Movement among study areas

- Very flexible and applicable to a range of situations

Example – breeding/non-breeding status



$$
\begin{array}{c c}
 & \begin{array}{cccc} \mathbf{J} & \mathbf{B} & \mathbf{N} & \mathbf{D} \end{array} \\
\begin{array}{c} \mathbf{J} \\ \mathbf{B} \\ \mathbf{N} \\ \mathbf{D} \end{array} &
\begin{bmatrix}
0 & \phi^J\psi^{JB} & \phi^J\psi^{JN} & 1-\phi^J \\
0 & \phi^B(1-\psi^{BN)} & \phi^B\psi^{BN} & 1-\phi^B \\
0 & \phi^N\psi^{NB} & \phi^N(1-\psi^{NB)} & 1-\phi^N \\
0 & 0 & 0 & 1
\end{bmatrix}
\end{array}
$$

Extensions of multistate models

- Range of applications, not just individual mark-recapture data
- Used in both estimation and projection
- Migratory connectivity
  - probability of moving among multiple breeding and wintering sites
- Multistate occupancy analysis
  - change in occupancy state of sites (e.g. many, few, or none detected, detected with and without breeding activity, etc.)
- Ecological succession
  - change in dominant land cover type over time

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Integrated Population Models (IPMs)

- Relatively new approach to combining all sources of demographic information into one analysis
    - Typically **counts**, **mark-recapture,** and some measure of **fecundity**
- Pros:
    - More precise estimates of demographic rates
    - Can potentially estimate things you don’t have explicit data about (usually these things are hard to measure)
        - Immigration/emigration, juvenile survival
    - Can directly project population into the future while propagating all uncertainty
- Cons:
    - More complicated analysis, requires more time/expertise to develop

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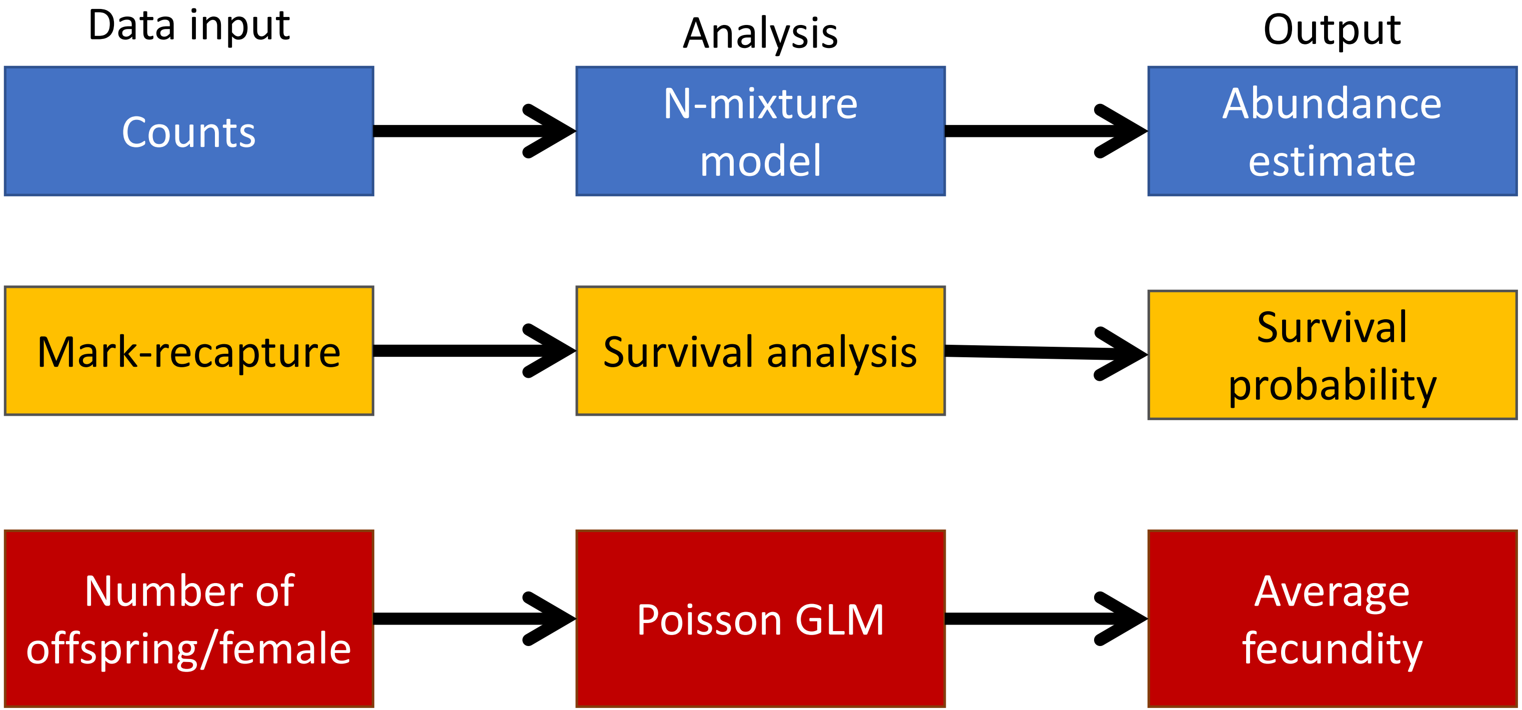
Non-integrated analysis



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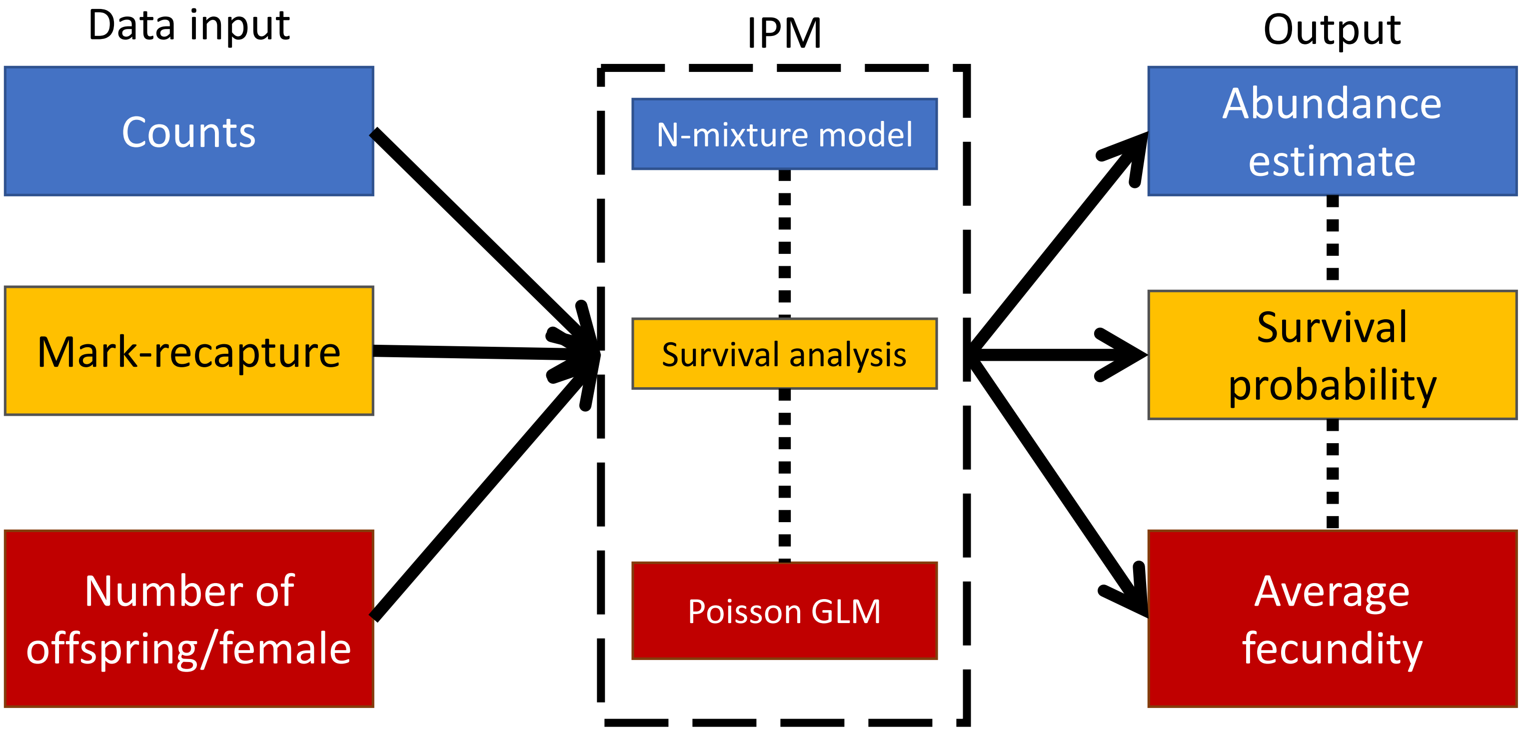
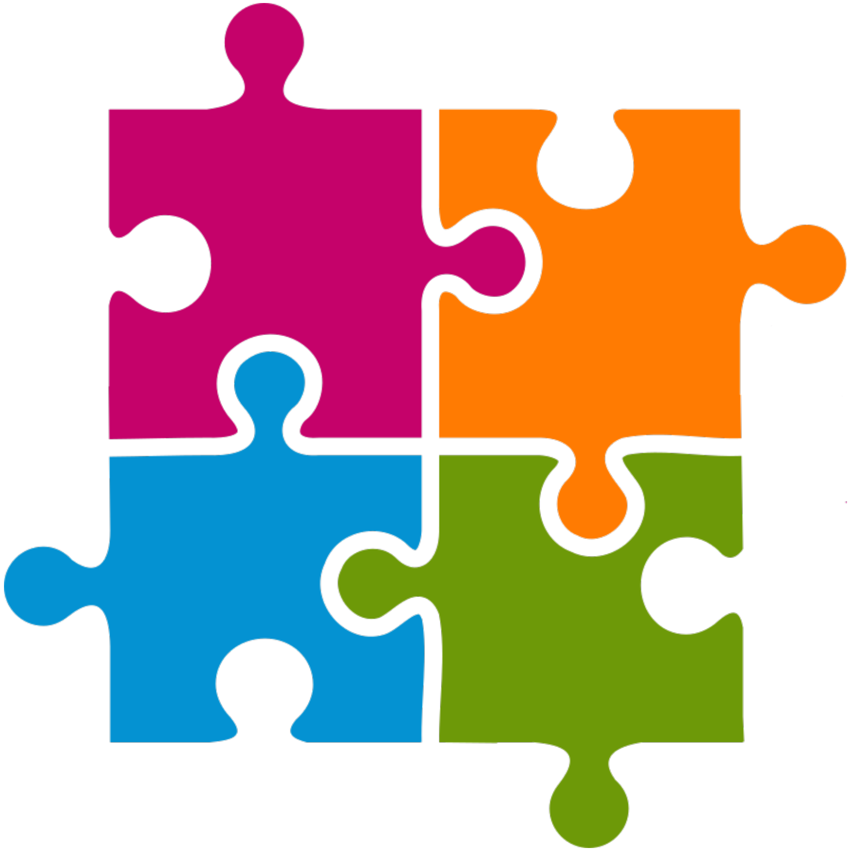
Integrated analysis



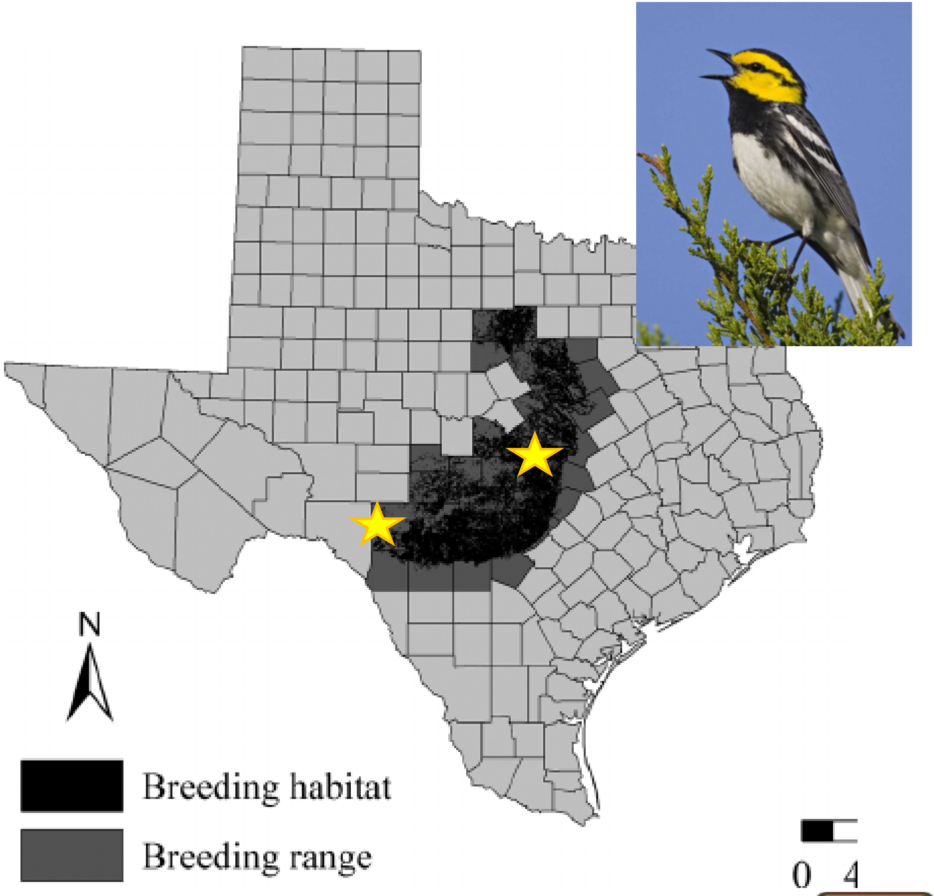
Change in population size = births + immigration - deaths - emigration

$\lambda =$



Do I need to use an IPM?

- Core assumption = all data are a product of the same underlying population processes
- Most useful when:
  - Individual analyses of different data sources give competing results
  - You want to estimate a demographic parameter without data (e.g. immigration rate)



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