Capture-mark-recapture methods for abundance estimation

Abundance estimation

Same old equation:

$$\hat{N} = \frac{n}{\hat{p}}$$

- N is abundance (population size)
- n is the number of individuals detected
- $\hat{p}$ is an estimate of detection probability: The probability of detecting an individual

Most methods differ in how they estimate p

Overview

Estimating p

- Set traps in a study area and mark each captured individual
- Repeat the trapping on K occasions
- On each occasion, mark new individuals and record recaptures
- If capture probability is high...
  - You will detect most of the population on the first occasion
  - Most of the captures on subsequent occasions will be recaptures
- And vice versa

Encounter histories

$n = 5$ individuals captured over 3 sampling occasions

	Occasion 1	Occasion 2	Occasion 3
Animal 1	0	0	1
Animal 2	1	1	0
Animal 3	1	1	1
Animal 4	1	0	0
Animal 5	0	1	0

These data tell us about p and hence N. Estimation is usually acheived using maximum likelihood methods.

Lincoln-Peterson Method

The original method was first used by Pierre-Simon LaPlace to estimate the human population in France.

Later it was used by Lincoln (shown above) and Peterson to estimate fish and wildlife populations

Lincoln-Peterson Study Design

- There are only 2 capture occasions
- On the first, n_1 animals are captured and marked
- On the second, n_2 animals are captured and m_2 of them are recaptures

Lincoln-Peterson Abundance Estimator

How can we use n_1, n_2, and m_2 to estimate N?

$$\frac{n_1}{N} = \frac{m_2}{n_2}$$

And so...

$$\hat{N} = \frac{n_1 n_2}{m_2}$$

Lincoln-Peterson Assumptions

(1) Population closure
- No births
- No deaths
- No immigration or emigration

(2) All individuals are assumed to have the same capture probability

(3) No tag loss or mis-identification

K-sample CMR

Using more than 2 sampling occasions has many advantages, including the ability to account for:

- Temporal variation
- Behavioral effects
  - Trap happiness
  - Trap shyness
- Individual heterogeneity
- Combinations of the above

Removal sampling

Suppose you remove individuals on each survey

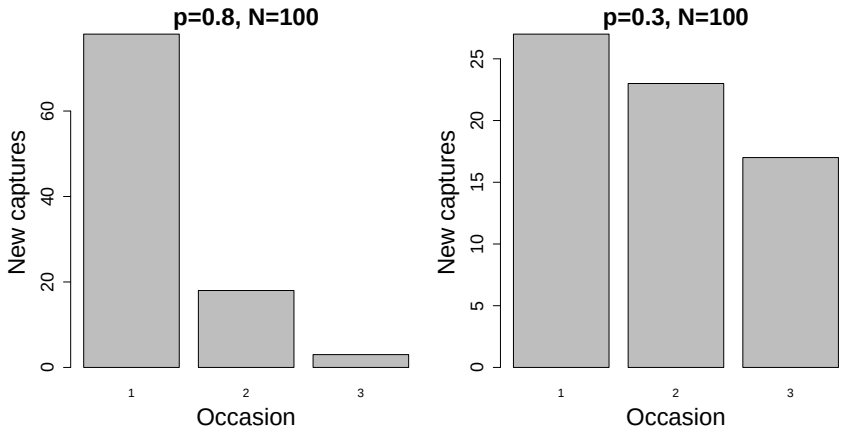
Eventually you should deplete the population

The number of captures you would expect on each occasion:

Occasion	Expected count
1	pN
2	$p(1-p)N$
3	$p(1-p)^2N$
4	$p(1-p)^3N$
⋮	⋮
K	$p(1-p)^{K-1}N$

Example

The rate at which the population is depleted tells us about p.



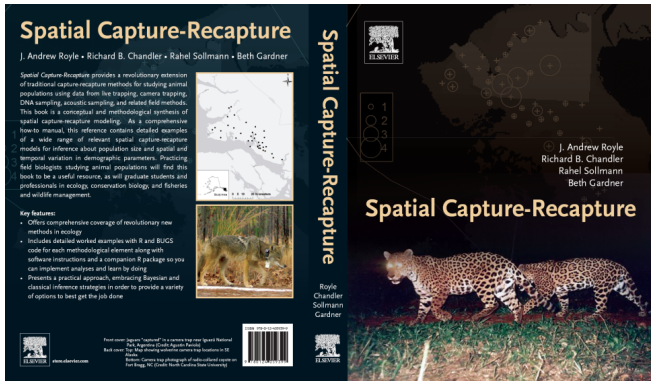
Summary

Key points

- Capture-recapture methods use information about recapture rates to estimate capture probability and abundance
- More advanced methods can be used to estimate density and vital rates
- Modern field methods use camera traps or DNA sampling techniques to collect non-invasive capture-recapture data

Lingering questions

- How do we convert abundance to density?
- What is the area surveyed?



Read Chapter 11