Mark-Recapture

Quantitative Analysis of Vertebrate Populations

Hierarchical Models

- Occupancy (distribution)
- Abundance
- Colonization-extinction
- Apparent survival
- Population dynamics

Best at landscape scale. Potentially coarse measures

Why Mark-Recapture

- More precise estimates of abundance
- Better estimates of apparent survival
- Estimates of true survival
- Individual growth rates
- Individual fecundity and other traits over time
- Home range estimates (spatial capture-recapture)

Why not mark-recapture

- Need to catch/trap in most cases
- Much more intensive (handling/marking time)
- Limited number of locations or populations
- Therefore can't related to landscapes very well

General Assumptions

- Marking individuals does not affect their catchability.
- Animals do not lose marks between sampling periods.

Marking

Figure 1: Marks

Mark-recpature options

- Closed populations
- Open populations
- Robust design
- Spatial capture-recapture (with above options)

Closed Populations

Lincoln-Peterson Estimate

- 2-session cohort mark
- individuals mix
- ratio of recaptures to captures = captures to total population
- all individuals = chance of capture

$$N = \frac{M * C}{R}$$

Lincoln-Peterson Assumptions

- The population is closed, so the size is constant.
- All animals have the same chance of being caught in the first sample.
- Marking individuals does not affect their catch-ability.
- Animals do not lose marks between the two sampling periods.
- All marks are reported on discovery in the second sample.

Closed Populations

- more than 2 sessions
- more precise estimates
- individually marked = individual heterogeneity
- trap happy or trap shy (behavioral)
- time varying detection/capture probability

Unequal Capture Probabilities

SOURCE OF BIAS	EXAMPLE	CONSEQUENCE	N
Capture heterogeneity	Some animals less likely to be caught (e.g. age-biased dispersal)	Marked animals have higher capture probabilities	Under-estimated
Capture heterogeneity	Inappropriate trapping method (e.g. not enough traps used)	Precludes some individuals from capture if trap already occupied	Under-estimated
Capture heterogeneity	Inappropriate trap placement (e.g. traps on edge of home range instead of middle)	Animals less likely to be captured, hence fewer animals marked	Under-estimated
Trap response	Trap-happiness (e.g. use of baited traps)	Animals caught once are more likely to be caught again	Under-estimated
	Trap-shyness (e.g. animals learn to avoid nets or traps in fixed places)	Animals caught once are less likely to be caught again	Over-estimated

Figure 2: unequal_caps

Closed population options

Full Likelihood

Conditional Likelihood (Huggins)

- Allows for covariates on capture probability

Constraining the last "p"

p = probability of first capture c = probability of recapture

history	*probability*
11	$p_1 c_2$
10	$p_1(1-c_2)$
01	$(1-p_1)p_2$
00	$(1-p_1)(1-p_2)$

Figure 3: capture_history

Closed Population Models

Otis notation	*Expanded notation*	*Description*
M_0	$\{f_0, p(.) = c(.)\}$	Constant p
M_t	$\{f_0, p(t) = c(t)\}$	Time varying p
M_b	$\{f_0, p(.), c(.)\}$	Behavioral response
M_h or M_{h2}	$\{f_0, p_a(.) = c_a(.), p_b(.) = c_b(.), \pi\}$	Heterogeneous p

Figure 4: closed_models

Open Populations

Robust Design

Spatial Capture-Recapture