Effects of switching to a two-wire hair sampling system for capture-mark-recapture analysis

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Outline

- Capture-Mark-Recapture basics and assumptions
- Non-invasive sampling
- Previous research
- Study area
- Methods
- Results
- Research implication and future directions

Capture-Mark-Recapture (CMR)

- Lincoln – Peterson Model:

$$\hat{N} = \frac{n_1}{\hat{p}}$$

$$\hat{p} = \frac{m_2}{n_2}$$

- **n_1** = # of *animals* captured in capture occasion1
- **n_2** = # of *animals* captured in occasion 2
- **m_2** = # of *marked* animals captured in occasion 2
- **p** = capture probability

Capture-Mark-Recapture (CMR)

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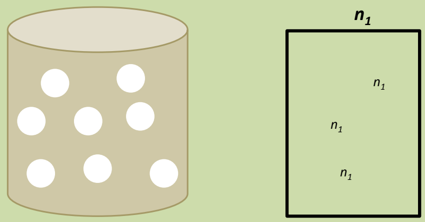

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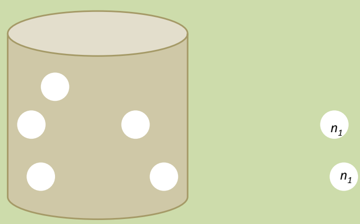
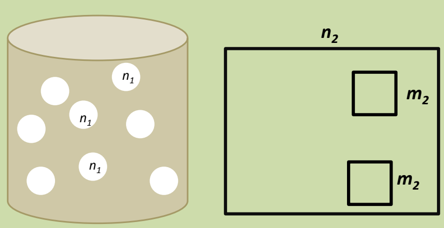


Capture-Mark-Recapture (CMR)

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

$n_1 = 3$
$n_2 = 4$
$m_2 = 2$



Capture-Mark-Recapture (CMR)

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

$n_1 = 3$
$n_2 = 4$
$m_2 = 2$

$$\hat{N} = \frac{3}{0.5} = 6 \qquad \hat{p} = \frac{2}{4} = 0.5$$

Capture-Mark-Recapture (CMR)

- Assumptions (Otis et al. 1978):
  1. Population is closed
  2. Marks are not lost
  3. Marks are correctly identified
  4. All individuals have an equal probability of capture and that probability does not change

Capture-Mark-Recapture (CMR)

4. All individuals have an equal probability of capture and that probability does not change
   - **Time** – Capture probabilities vary over time
   - **Behavioral** – Capture probabilities change due to a behavioral response from being captured (e.g., “trap-happy” or “trap-shy”)
   - **Heterogeneity** – Capture probabilities differ by individual (e.g., females with cubs vs. females without)
     - Huggins (1991) – Use of individual covariates
       - weight, age, or capture frequency
     - Pledger (2000) – Mixture Models
       - 2 proportions (π) of the population with different capture probabilities
       - Hard to catch (π) vs. Easy to catch (1- π)

Capture-Mark-Recapture with Heterogeneity Mixtures

Lincoln – Peterson Model:

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

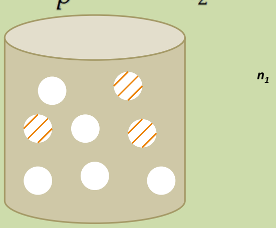
Capture Probabilites Using Pledger's Mixture Models:

$$\hat{p} = \pi_L * p_L + \pi_H * p_H$$

Capture-Mark-Recapture with Heterogeneity Mixtures

$$\hat{p} = \pi_L * p_L + \pi_H * p_H$$

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

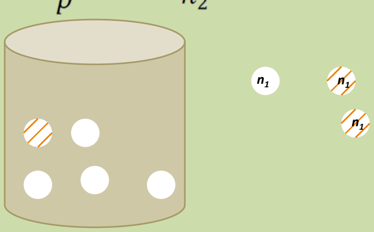


- n_1 = # of *animals* captured in capture occasion1
- n_2 = # of *animals* captured in occasion 2
- m_2= # of *marked* animals captured in occasion 2
- π_L = Proportion of individuals with a low capture probability
- π_H = Proportion of individuals with a high capture probability

Capture-Mark-Recapture with Heterogeneity Mixtures

$$\hat{p} = \pi_L * p_L + \pi_H * p_H$$

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



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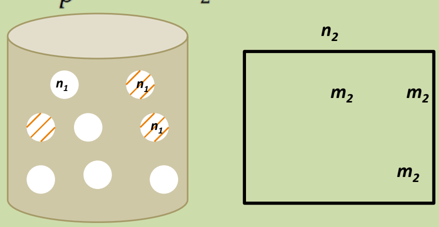

Capture-Mark-Recapture with Heterogeneity Mixtures

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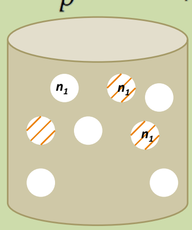


- n_1 = 3
- n_2 = 4
- m_2 = 3
- π_L = Proportion of individuals with a low capture probability
- π_L = 5/8 = 0.675
- π_H = Proportion of individuals with a high capture probability
- π_H = 3/8 = 0.325

Capture-Mark-Recapture with Heterogeneity Mixtures

$$\hat{p} = 0.675 * \frac{1}{4} + 0.325 * \frac{3}{4}$$

$$\hat{p} = 0.437$$

$$\hat{N} = \frac{3}{\hat{p}}$$

$$\hat{N} = \frac{3}{0.437} = 6.3$$

- n_1 = 3
- n_2 = 4
- m_2 = 3
- π_L = 5/8 = 0.675
- π_H = 3/8 = 0.325

Capture-Mark-Recapture with Heterogeneity Mixtures

$\hat{p} = 0.675 * \frac{1}{4} + 0.325 * \frac{3}{4} = 0.437$

$\hat{p} = 0.437$

$\hat{N} = \frac{3}{\hat{p}}$

$\hat{N} = \frac{3}{0.437} = 6.3$

$\hat{p} = \frac{3}{4} = 0.75$

$\hat{N} = \frac{3}{\hat{p}}$

$\hat{N} = \frac{3}{0.75} = 4$

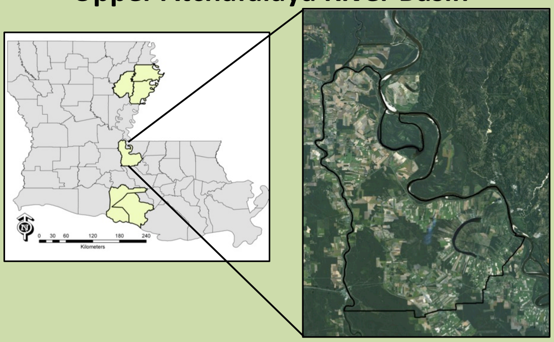
Capture-Mark-Recapture (CMR)

- **Capture Probabilities**
  - Heterogeneity – "Bane of CMR's existence"
    - Hard to measure
    - Minimize or quantify it as much as possible to get reliable population estimates (Petit & Valiere 2006)
  - Biased *p*
    - High → Underestimate *N*
    - Low → Overestimate *N*
  - Want *p* as high as possible (>0.20)
    - Reduces chance that heterogeneity will go undetected
    - Can be low due to trap bias or trapping effort

Non-invasive sampling

- Uses DNA as marker
  - Collection of hair, feces, or feathers
- No physical handling of the animal
  - Goal to reduce negative ("trap-shyness") behavioral biases after first capture
- Increase sampling area and effectiveness
  - Can cover a larger area and increase the number of "traps" in the study area

Study Area: Upper Atchafalaya River Basin



Sampling Methods

- Study began in 2007
- 4 hair sites per home range
- Grid 1.6 km^2
- Strands of barbed-wire were stretched across 3-4 corner trees
- Sites were baited and scent lure was hung

Sampling Methods

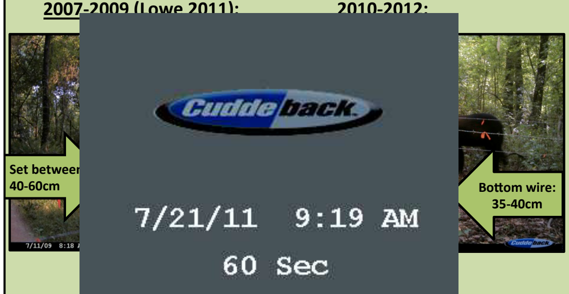
- Sites were checked every 7 days for 8 weeks
- Hair was collected if >5 guard hairs or >20 under-fur hairs.
- Samples were sent to Wildlife Genetics International for analysis.
- WGI sub-sampled criteria: 25 samples/week

Methods

2007-

Change in Methods

2007-2009 (Lowe 2011): **2010-2012:**



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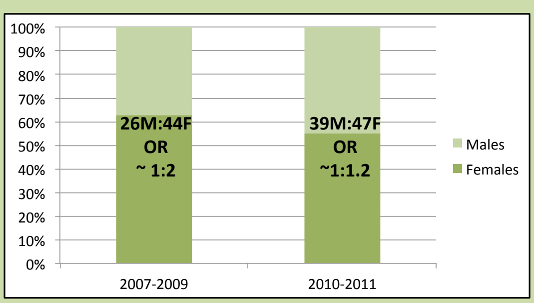

Change in Methods

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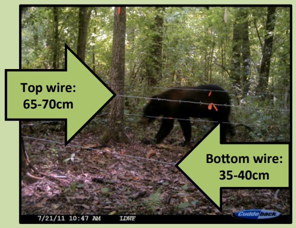

Overall Question:
How does the addition of a second wire affect the estimates of population parameters?

Change in Methods

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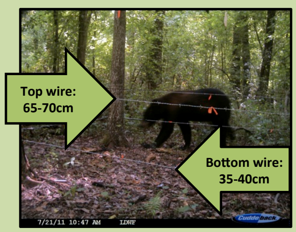

Hypothesis:
Proportion of hard to catch males (π_L) will decrease in year 4 of sampling due to the addition of a second wire.

Methods: Data Analysis

- Data from 2007-2010 (2011 excluded)
- Program MARK (White and Burnham 1999)
  - Closed capture with heterogeneity
    - π , p, & N
  - Constant (.)
  - Group effects (g)
  - Time dependent (t)
  - One vs. Two-wire (Wire)
  - One vs. Two-wire for Males (Wire Male)
- AIC for Model Selection

Model Set

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
{pi(.), p(g), N(t*g)}	899.0029	0	0.24011	1	12	675.4288
{pi(wire), p(g), N(t*g)}	899.1548	0.1519	0.22254	0.9268	13	673.5403
{pi(wire male), p(g), N(t*g)}	899.6355	0.6326	0.175	0.7288	13	674.021
{pi(g), p(g), N(t*g)}	900.8414	1.8385	0.09576	0.3988	13	675.2268
{pi(g+wire), p(g), N(t*g)}	901.0461	2.0432	0.08644	0.36	14	673.3878
{pi(wire male), p(wire male), N(t*g)}	901.6381	2.6352	0.06429	0.2678	14	673.9798
{pi(g+wire), p(g+wire), N(t*g)}	902.1512	3.1483	0.04975	0.2072	15	672.4461
{pi(g), p(g+wire), N(t*g)}	902.6771	3.6742	0.03824	0.1593	14	675.0189
{pi(g+wire), p(g), N(g*t)}	904.4021	5.3992	0.01614	0.0672	16	672.647
{pi(wire), p(t+g), N(t*g)}	905.9987	6.9958	0.00727	0.0303	22	661.8763
{pi(wire), p(wire), N(t*g)}	907.2976	8.2947	0.0038	0.0158	13	681.683
{pi(g+wire), p(g+wire), N(g*t)}	911.5275	12.5246	0.00046	0.0019	20	671.5404
{pi(g), p(g), N(g)}	913.6904	14.6875	0.00016	0.0007	26	661.2586
{pi(g), p(g), N(g*wire)}	916.5476	17.5447	0.00004	0.0002	27	662.0303
{full}	918.7587	19.7558	0.00001	0	30	657.9652

Model Set

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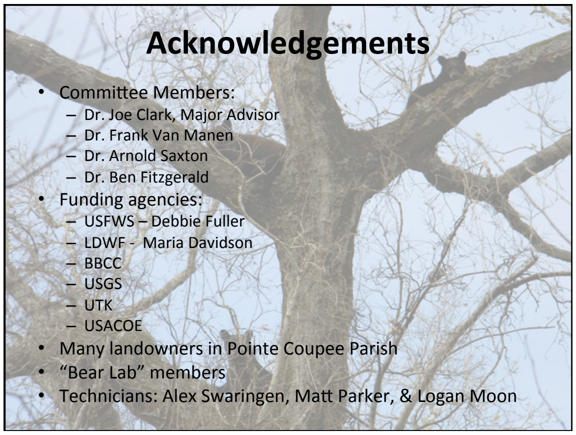
β (wire), β (wire male), and β (g + wire) did not differ from zero

Research Implications & Future Directions

- No over-whelming results
- Needs more data
  - Comparing 3 years vs. 1 year of data
  - Increase sub-sample size
  - 2012 data
- Continue with 2-wire system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– Dr. Ben Fitzgerald
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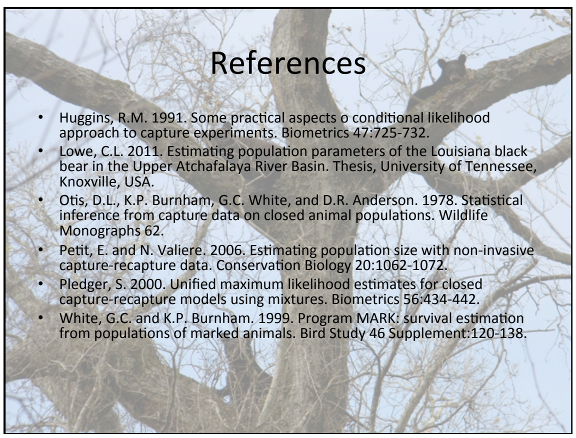
• "Bear Lab" members
• Technicians: Alex Swaringen, Matt Parker, & Logan Moon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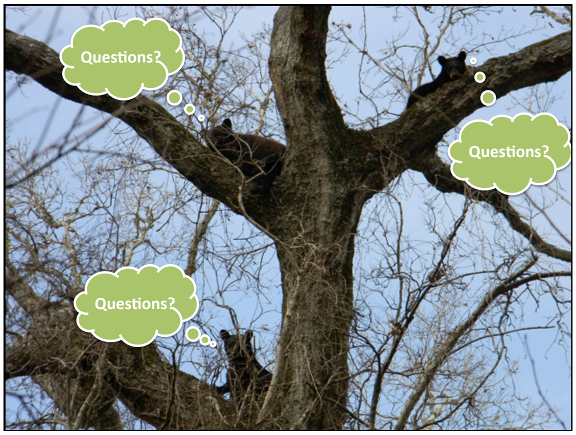
Questions?
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