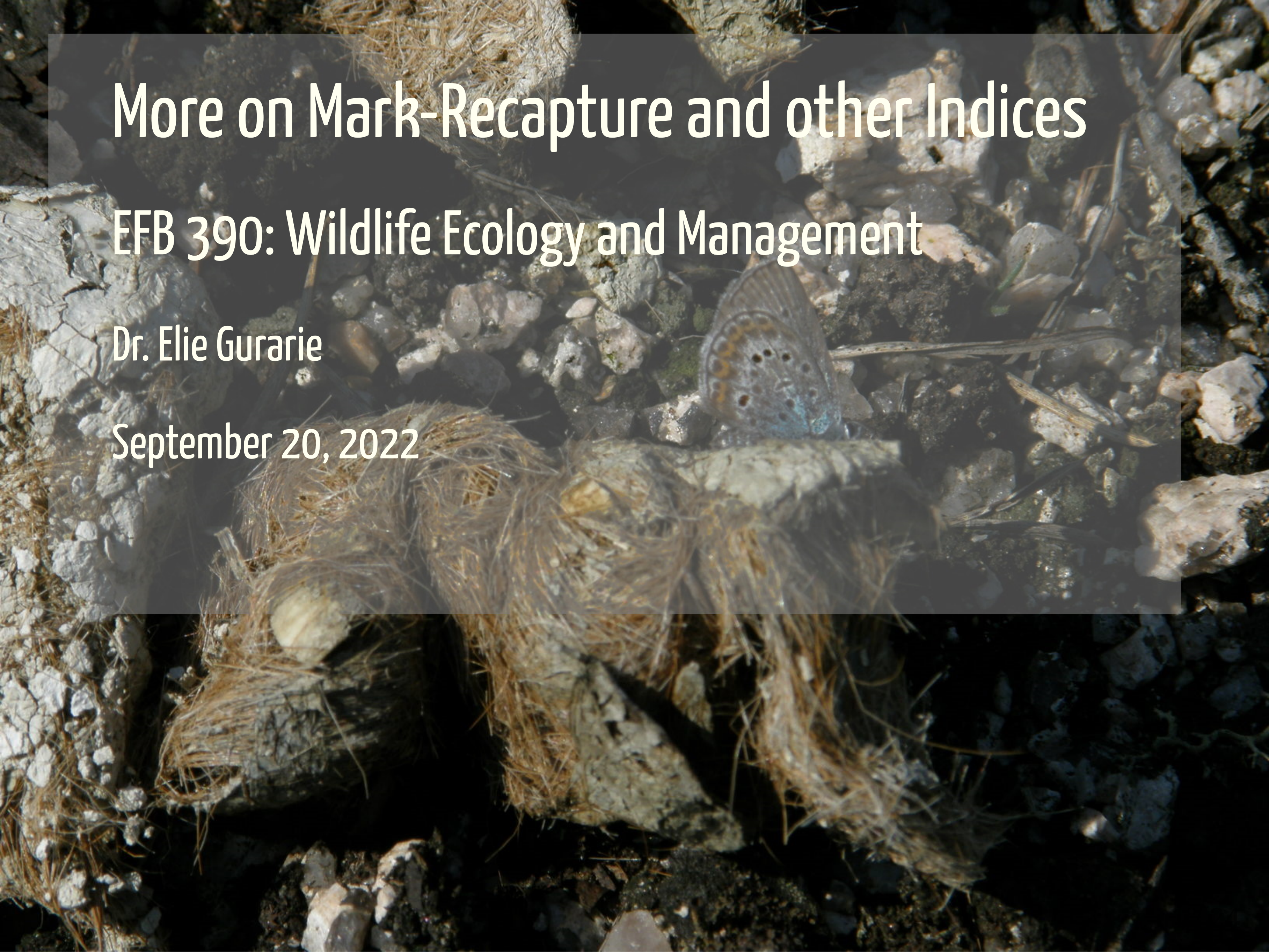


More on Mark-Recapture and other Indices

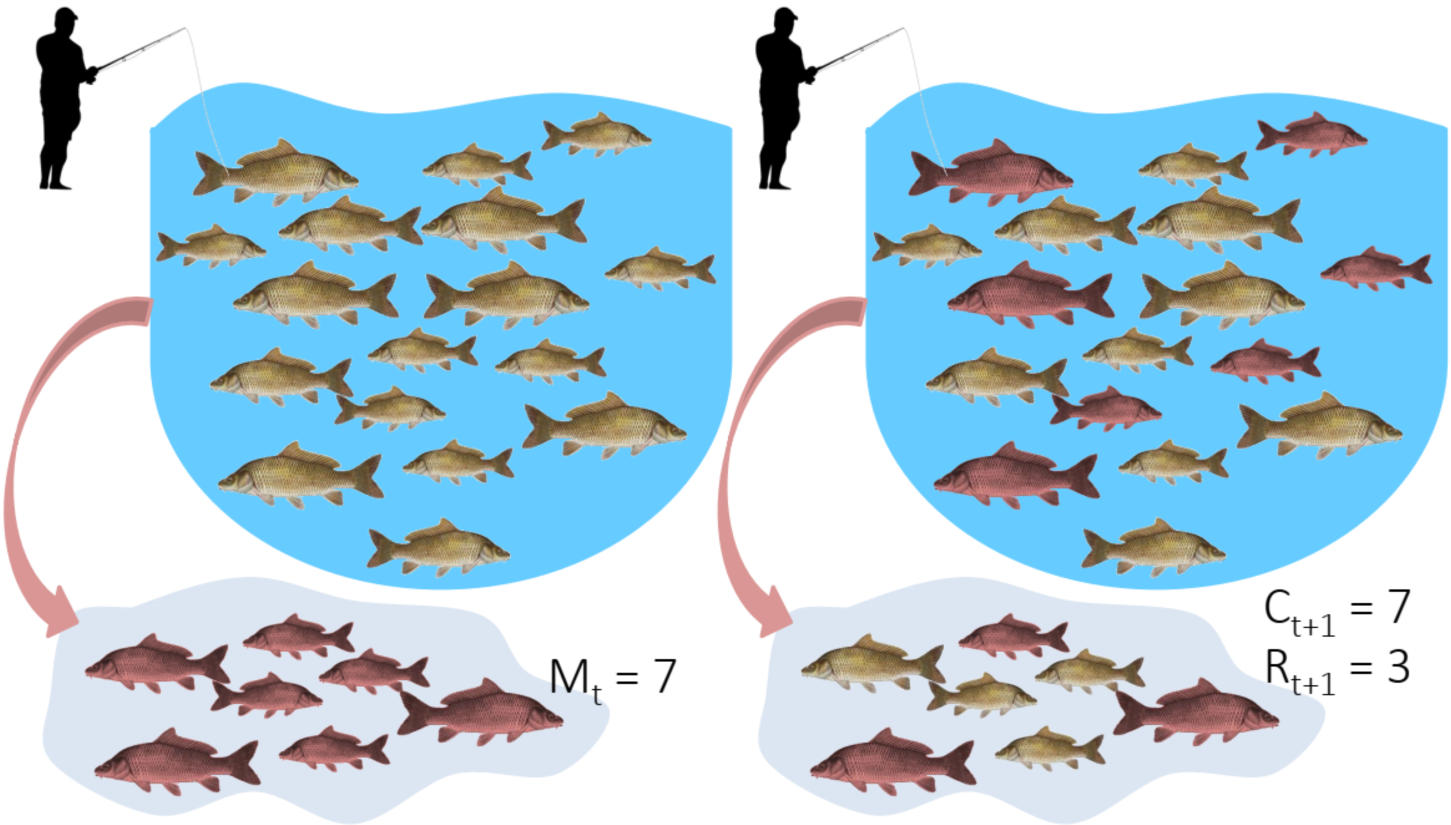
EFB 390: Wildlife Ecology and Management

Dr. Elie Gurarie

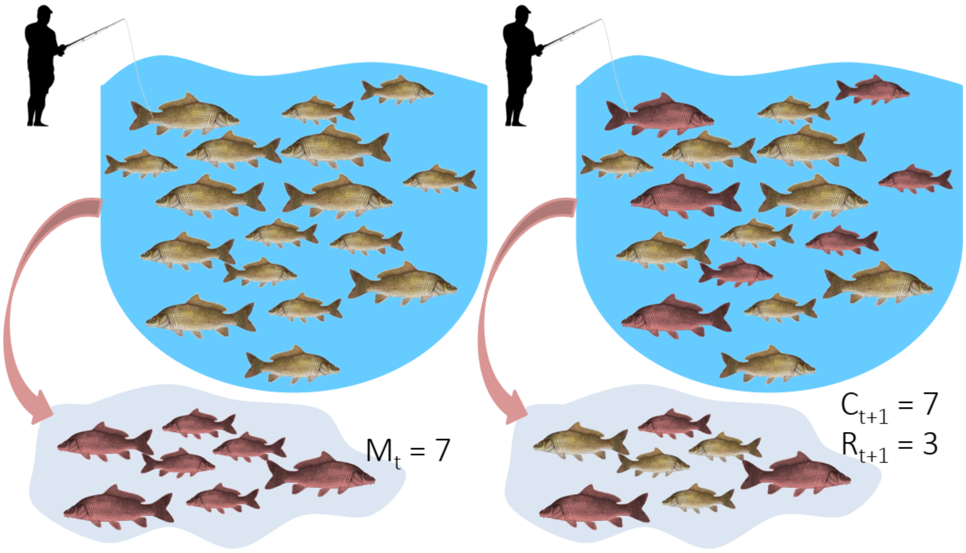
September 20, 2022

Mark-Recapture is Super Simple

1. mark random subset, 2. release, 3. recapture, 4. count marked



Mark-Recapture



Convert that to estimate:

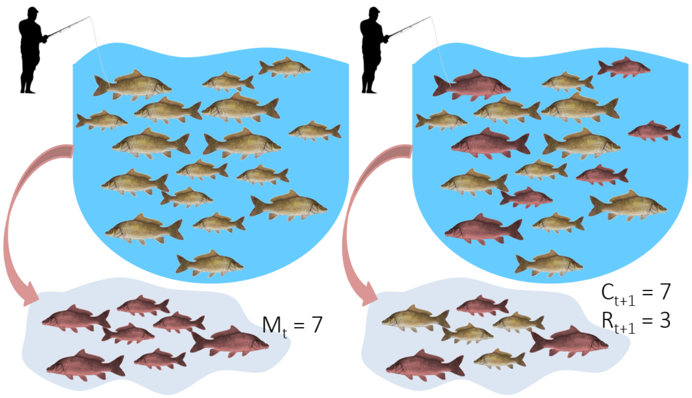
$$\widehat{N} = \frac{M \times C}{R}$$

Lincoln-Petersen Index

Basic idea, **ratios should be similar**:

$$\frac{marked\,(M)}{total\,(N)} = \frac{marked\,in\,recapture\,(R)}{recapture\,(C)}$$

Mark-Recapture



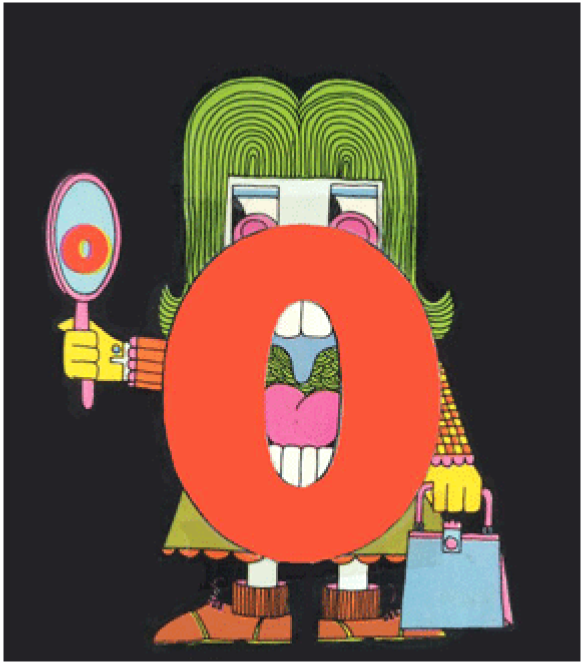
Point Estimate:

$$\widehat{N} = \frac{M \times C}{R}$$

And (approximate) precision:

$$SE(\widehat{N}) = \sqrt{\frac{M^2(C+1)(C-R)}{(C+1)^2(C+2)}}$$

I banded students!



… by going back in time and elaborately manipulating family histories so that exactly

$$\mathbf{M_t = 30}$$

of you have the letter

O

in your last name.

How many O's?

You have **5 minutes** to ask as many students in the class as you can (but not more than 20).

Ask whether they have an **"O"** in their last name.

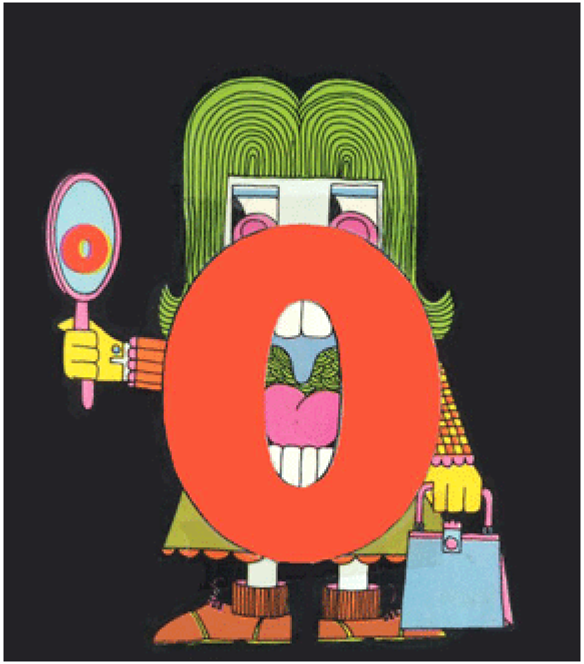
Count yourself!

Report your results here:

Remember, your sample should be **random**! (*do not seek out 'O's*).

https://forms.gle/JpVNNjxpsHcTRM3a9

Pause to compute the results



Important assumptions of the Lincoln-Petersen Index

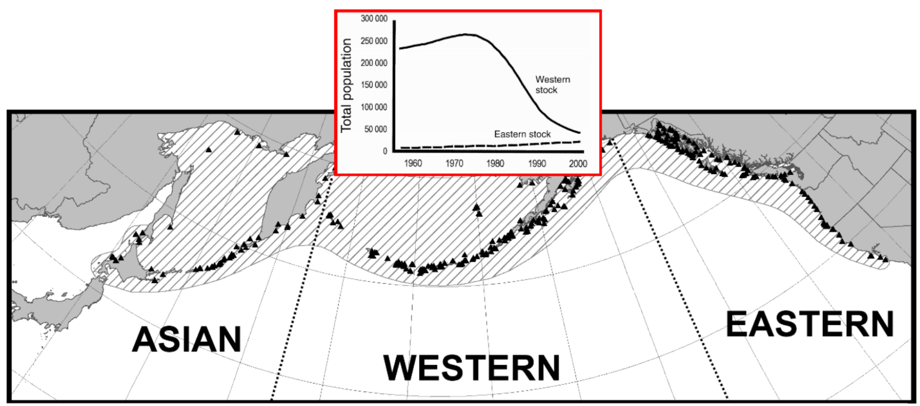
1. No deaths | no births
2. No immigration | no emigration
3. Random and equal probability sampling of marked and unmarked
4. No marks get lost

Do these assumptions hold for the Great Banded Student Count?

But when they don't hold

and if you go deep into statistical methods, you can learn a lot…

for example about Steller sea lions (*Eumetopias jubatus*).



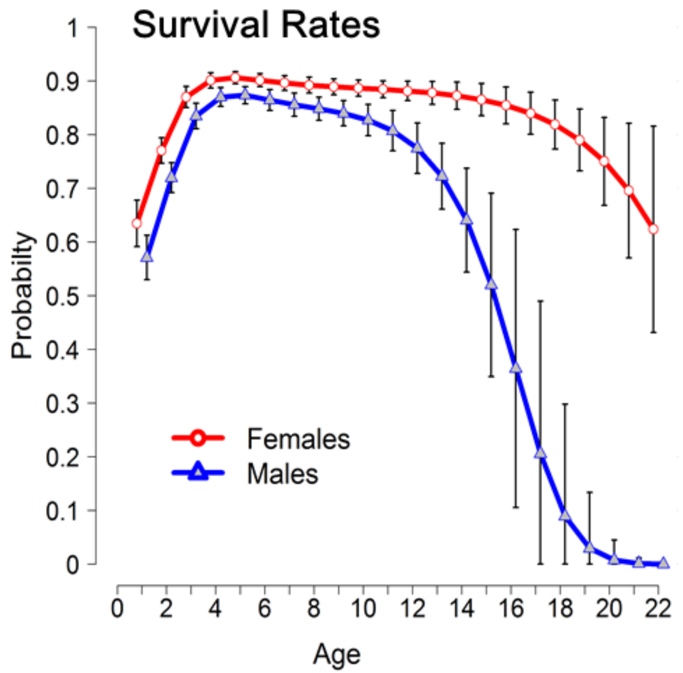
Mark-recapture study (since 2004)

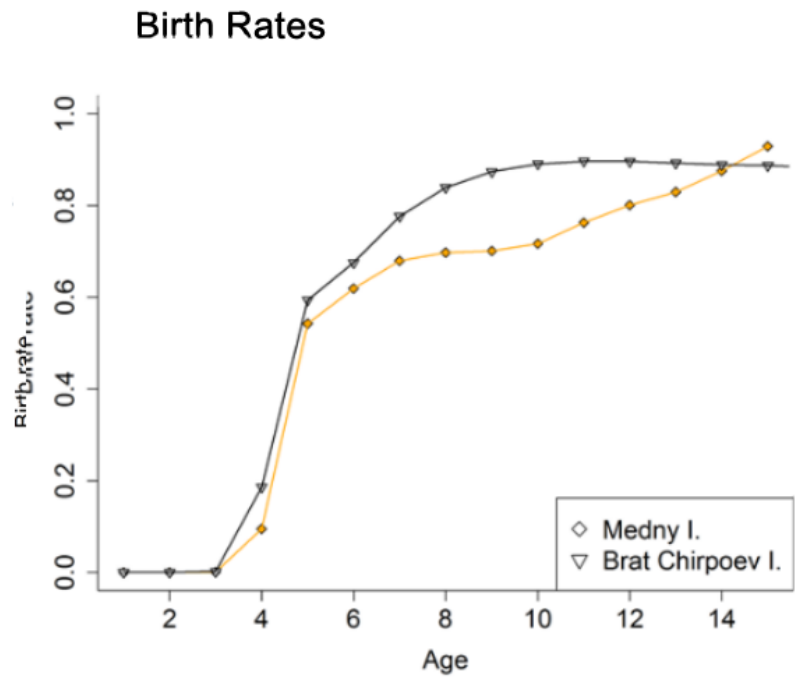
- $>$ 200,000 - daily resights
- $>$ 4,765 animals - all photo controlled
- $>$ 40,000 - photos of marked animals

Estimates of:

- Survival
- Reproduction rates
- Migration

AFAIK - the best age-specific vital rates of any large mammal.





Altukhov, A. et al. (2015) PLoS One 10(5):e0127292

Non-invasive mark-recapture

Day in the Life of a Wildlife Biologist

Non-invasive mark-recapture

- Visual identification of natural markings
  - Camera traps
  - Binoculars
- Fur snags - (**genetic mark-recapture**)
- Fecal samples - (**genetic mark-recapture**)

camera traps

fur snags

natural markings

scat

Example of estimates based on genetic mark-recapture

Eurasian otter (*Lutra lutra*).
Elusive, aquatic, nocturnal.

Deposits: ***spraint***

Spraint

From Wikipedia, the free encyclopedia

Spraint is the dung of the otter.[1]

Spraints are typically identified by smell and are known for their distinct odors, the smell of which has been described as ranging from freshly mown hay to putrefied fish.[2] The European otter's spraints are black and slimy, 3–10 cm (1–4 in) long

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Methods:

1. Collect spraint
2. Genotype microsatellites
   - those are the marks
3. Recapture (of spraint) proceeds as before

Using 2132 otter faeces of a wild otter population … collected over six years (2006–2012) … We provide precise population size estimate with confidence intervals (for 2012: $\widehat{N} = 20 \pm 2.1$, 95% CI $= 16$–25)

(Lampa et al. 2015, PLOS)

Index counts

are indirect observations which can be *related* to total abundances OR which can be useful for detecting trends / comparisons where you don't care (or can't get) absolute abundances.

Examples:

- Bird calls
- Nest counts
- Roost counts
- Animal tracks
- Fecal counts

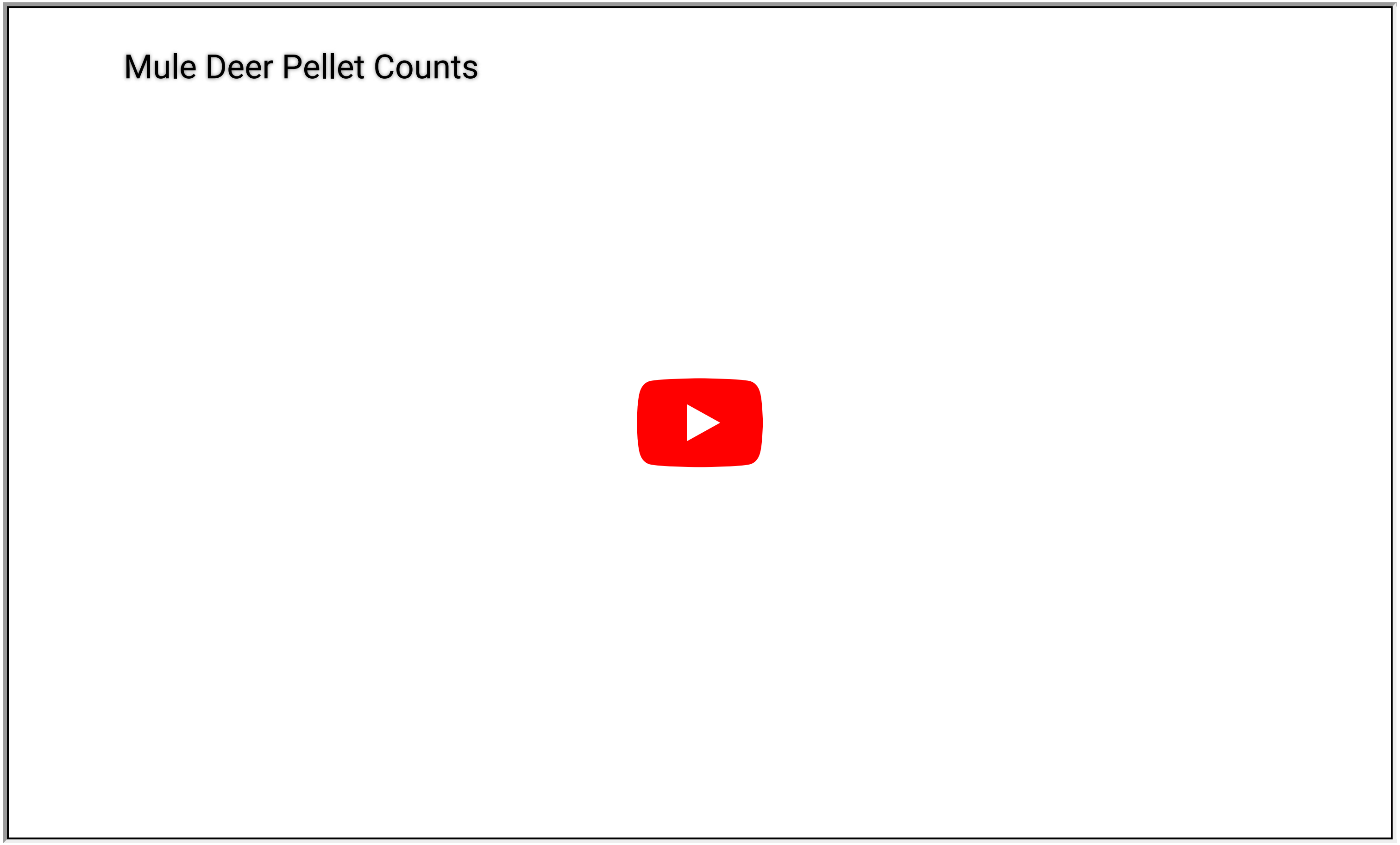
Studies in Avian Biology No. 6:76–80, 1981.

INDIRECT ESTIMATES OF ABUNDANCE OF BIRDS

EVELYN L. BULL[1]

ABSTRACT.—Relative density can answer many questions regarding bird populations, precluding the necessity of taking the additional time and expense to determine absolute density. Indirect indices of relative density include auditory signals, feeding and dusting sites, and track, roost, fecal, and nest counts. Their use assumes these indicators are related to the population size.

Fecal counts



Index-manipulation-index method

1. Obtain one index of population size: I_1
2. Remove a bunch of animals C
3. Obtain another index of population size: I_2

Then ...

$$\widehat{N_1} = \frac{I_1 C}{I_1 - I_2}$$

$$SD(\widehat{N_1}) = \widehat{N_1} \frac{q^*}{p^*} \sqrt{\frac{1}{I_1} + \frac{1}{I_2}}$$

- p^* is proportion removed: $\frac{I_1 - I_2}{I_1}$
- q^* is proportion remaining: $1 - p^*$

Very important assumption: Closed population, i.e. no births / deaths / emigration

Feral horse - fecal index + cull + fecal index

Data:

$I_1 = 301; I_2 = 76$

$C = 357; p* = 0.748$

Feral horses - Beaty's Butte, Oregon

Estimates:

$$\widehat{N_1} = (301 \times 357)/(301 - 76) = 478$$

with standard error:

$$SE(Y1) \approx 478 \times (0.252/0.748) \times \sqrt{(1/301 + 1/76)} = 21$$

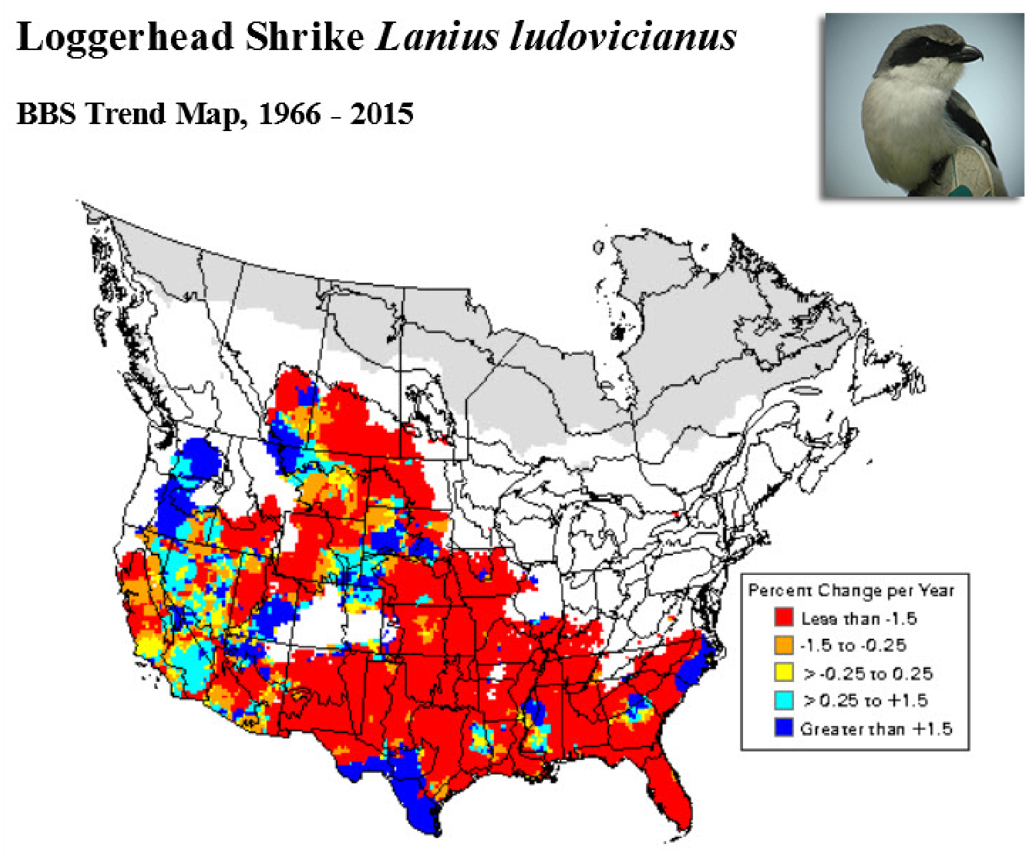
(see: Eberhardt 1982)

North American Breeding Bird Survey

Based mainly on volunteer expert birder detection of male breeding songs.

North American Breeding Bird Survey

Good for identifying large-scale trends … but hard to get abundance estimates:



Counting tracks

Used widely in Russia and Finland in standardized, repeated, long-term random transects.

Method: ski, and count (and ID) every track you cross

Confersion to density estimate:

Formozov–Malyshev–Pereleshin (FMP)

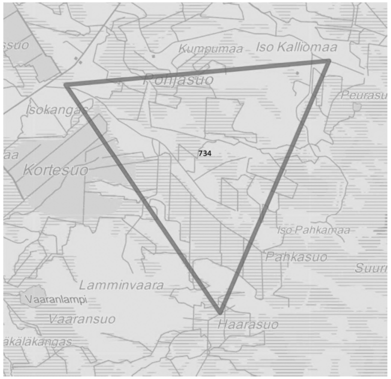
$$\widehat{D} = \frac{\pi}{2}\frac{x}{S\hat{M}}$$

where:

- x - number of track crossings
- S - transect length
- M - animal movement length

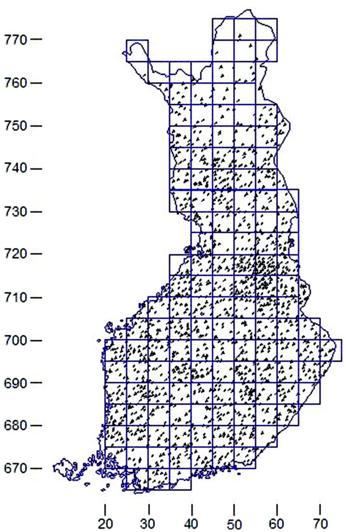
Very simple, surprisingly effective.

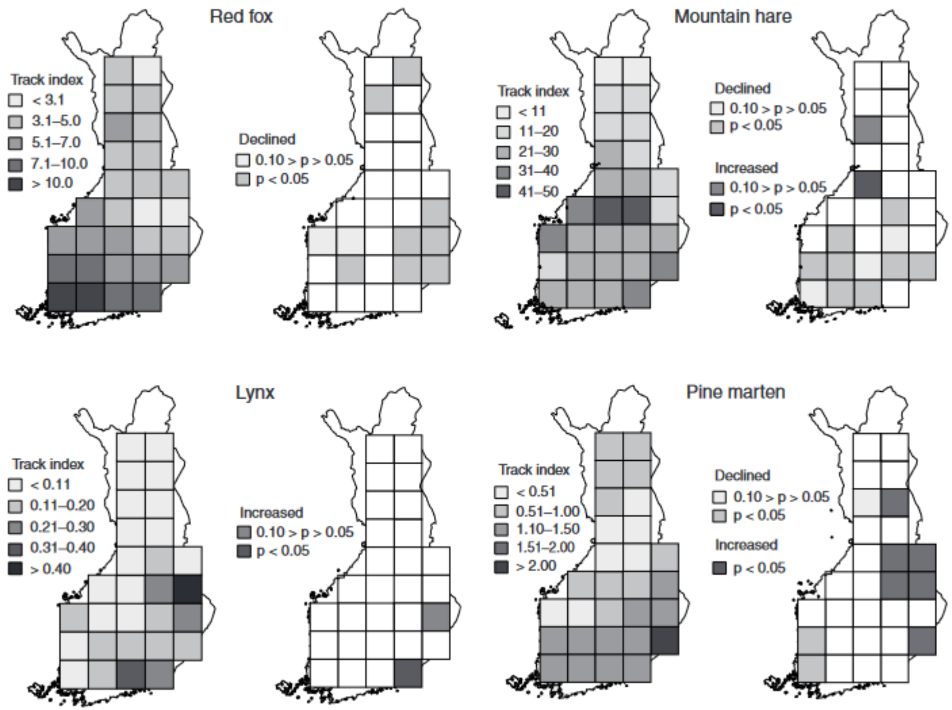
Finland Wildlife Triangles



4 km / side x 3

Note intense coverage!



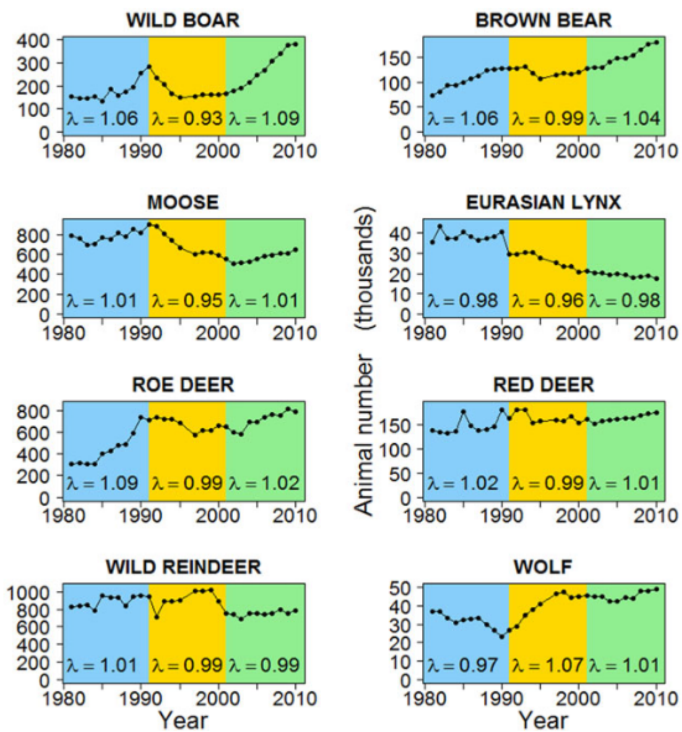


Detecting trends, and inferring predator-prey interactions.

(Kauhala and Helle 2000)

Large-scale patterns

50,000 transects between 1950-2010



Moose trends

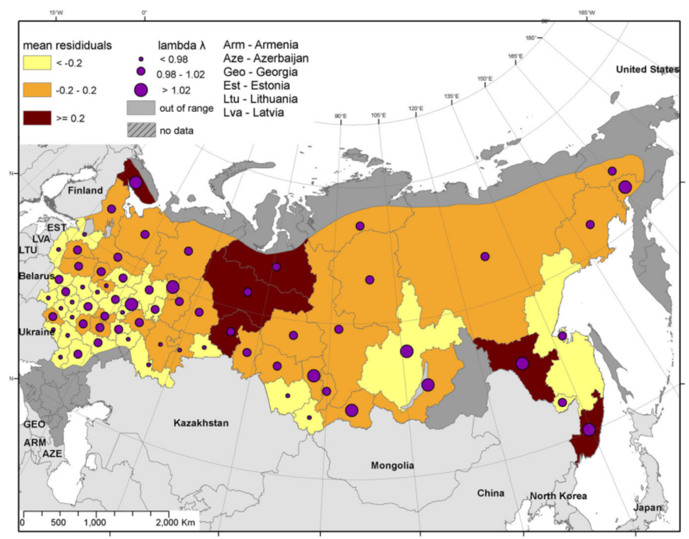


Figure 3. Map of moose population trends after the collapse of the Soviet Union. Magnitude of mean residuals reflects population growth rate in 1990s. Per capita population growth rate (λ) shows absolute population trend in 1990s. For similar maps for the other species, see Supporting Information.

Reveal impact of socioeconomic upheaval on wildlife.

(Bragina et al. 2015)

Take-aways

Thinking about **abundance estimation** helps us think about: (a) tools for oberving and monitoring wildlife, (b) creative ways to make inferences about wildlife, (c) some of the sources of randomness and variability that characterize *ALL* observations of wildlife.

Total counts

- expensive
- hard
- possible for few animals

Sample counts

- involve stats and good design
- possible for more animals

Mark-Recapture

- can give you MORE than just a count!
- requires long-term, multiple sampling
- some strong assumptions (if just abundance)
- often (not always) invasive

Index counts

- Least invasive
- Least precise estimates
- Can be scaled up - see growth of Citizen Science
- Useful for relative differences and trends

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