Sampling and the fossil record: Intro to CMR

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CENSUS VERSUS SAMPLING

1920 Census 2,649,775 persons in Norway

2022 UN estimates 5,434,319
2022 SSB estimates 5,435, 536

CENSUS VERSUS SAMPLING

1920 Census 2,649,775 persons in Norway

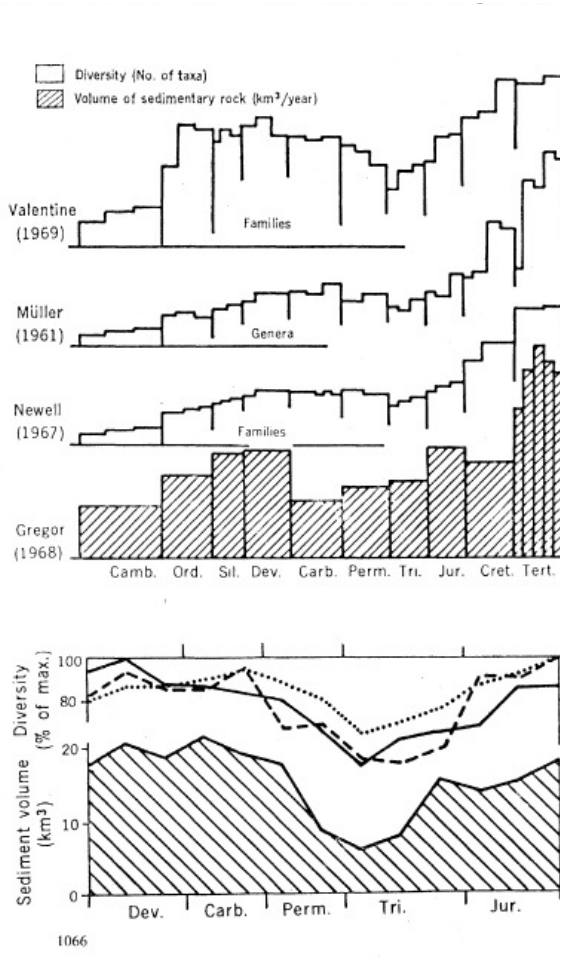
2022 UN estimates 5,434,319
2022 SSB estimates 5,435,536

Q1 What is the difference between a census and a sample?

Q2 Why not always do a census?

Q3 Why are the UN and SSB numbers different?

SAMPLING IN THE FOSSIL RECORD



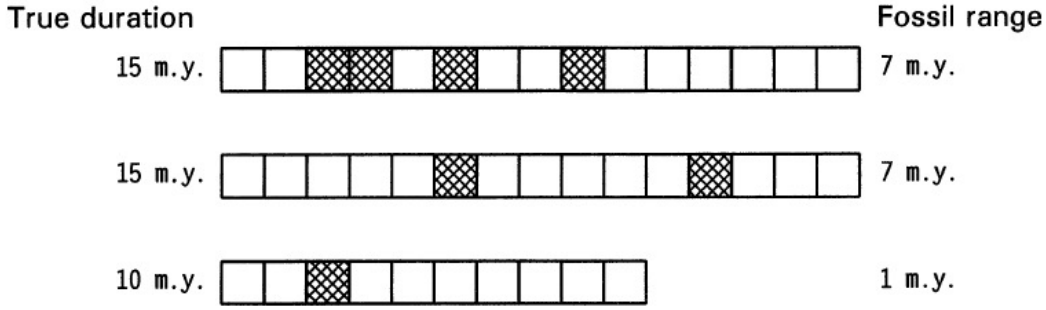
Raup 1972: Taxonomic diversity during the Phanerozoic. *Science*

- "systematic biases exist in the raw data ….. actual diversity picture may be quite different from that afforded by a direct reading of the raw data."

- "In spite of the fact that the patterns in Fig. 1 are correlated, a a causal relationship is by no means demonstrated.

SAMPLING IN THE FOSSIL RECORD

Foote & Raup 1996 Fossil preservation and the stratigraphic ranges of taxa. *Paleobiology*



R = Prob(preservation at least once in interval)
$(1 - R)$ = Prob(non-preservation)

In general, Prob(range = t if duration = T):

$= (1 - R)^T$ if t = 0

$= T(1 - R)^{(T - 1)}R$ if t = 1

$= (T - t + 1)(1 - R)^{(T - t)}R^2$ if t > 1

FOSSIL RECORD DATABASES

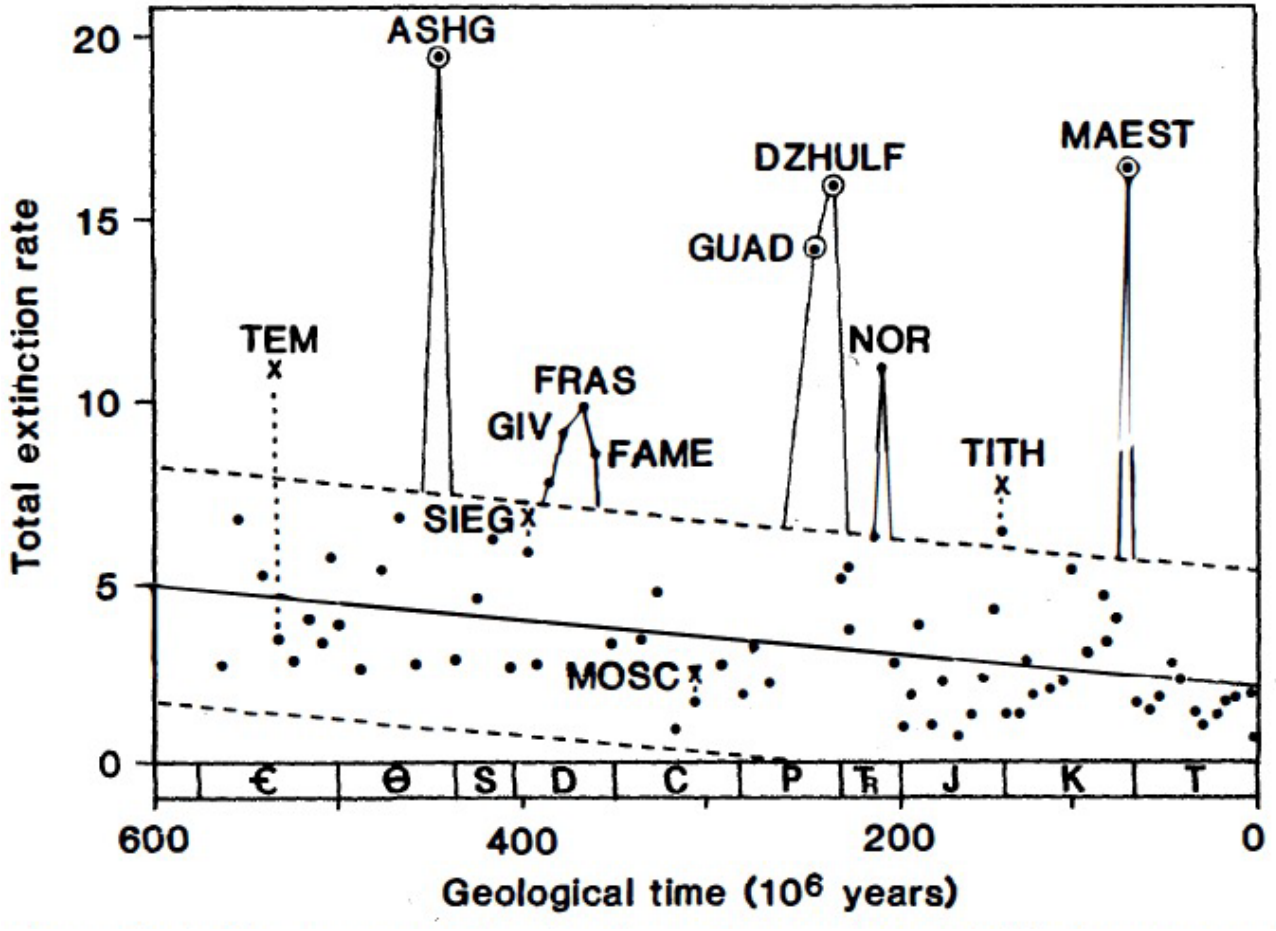
Sepkoski J. J., Jr (1992). A compendium of fossil marine animal families, 2nd edition. *Contributions in biology and geology*, *83*, 1–156.

Family stratiragphic ranges (first and last observations in time)

Huge community effort; NSF funding

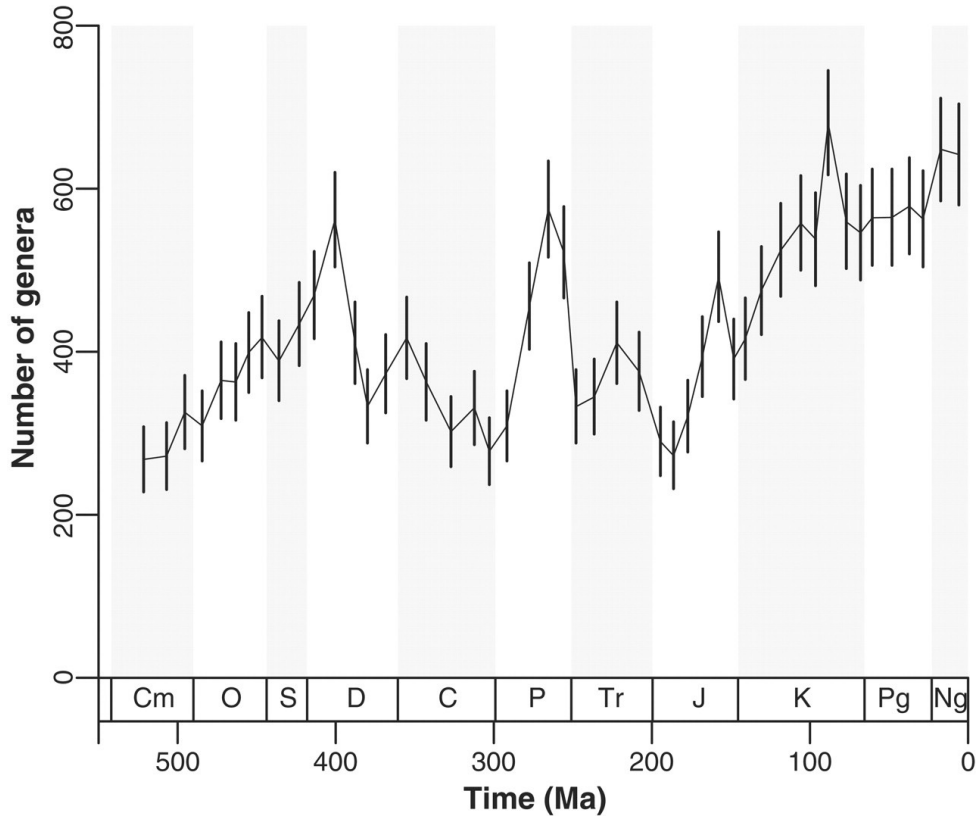
Taxon observations in space and time (species, genus etc, multiple observations)
Much more information!

FOSSIL RECORD DATABASES: MASS EXTINCTIONS

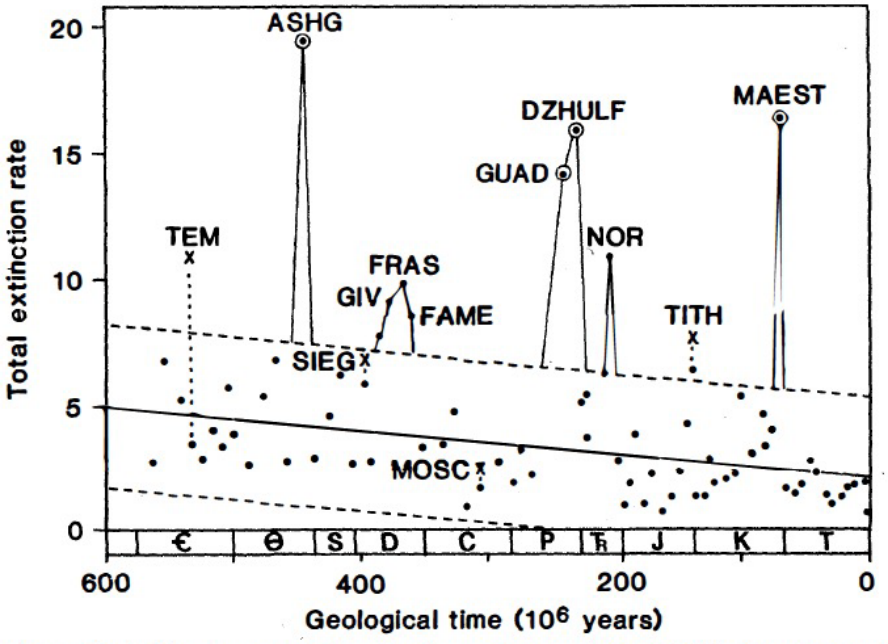


Raup & Sepkoski. 1982: Mass extinctions in the marine fossil record. *Science*

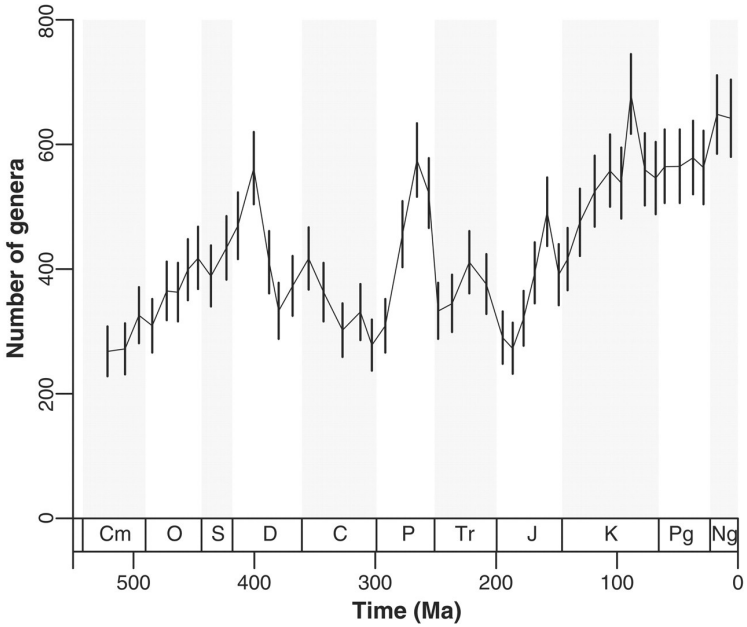
LESS DRAMATIC TRENDS WITH STANDARDIZATION



Alroy, J. *et al.* 2008 Phanerozoic Trends in the Global Diversity of Marine Invertebrates. *Science*



- Family level data
- First and last observations
- Range through



- Genus level data
- Observations in time intervals
- Sampling-standardized

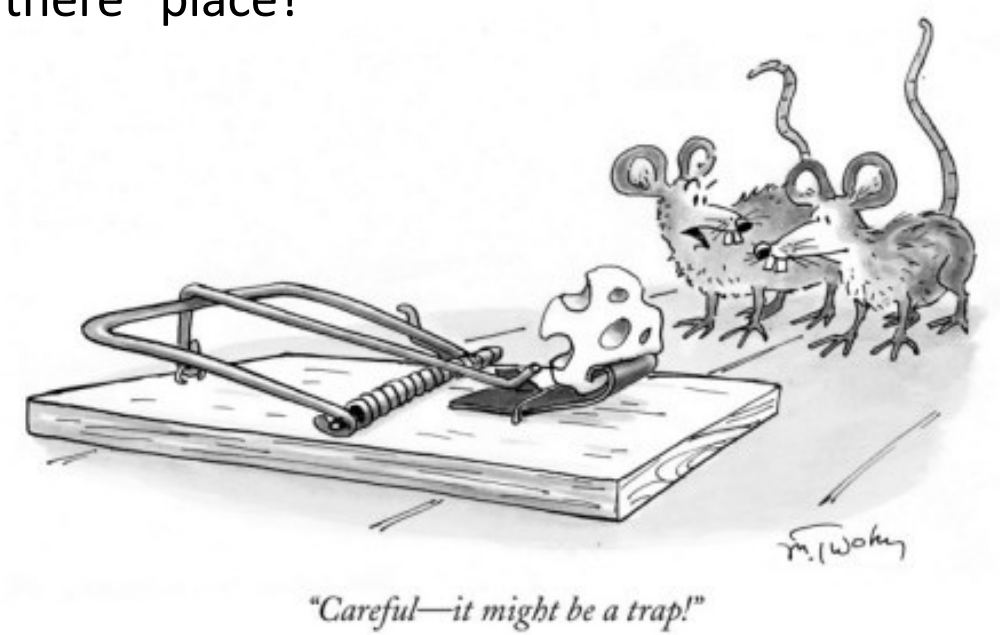
SWTICHING GEARS TO RATS/MICE

SWTICHING GEARS TO RATS/MICE

Day 1: caught 10 rats

Day 2: caught 2 rats

How many rats are there “place?”

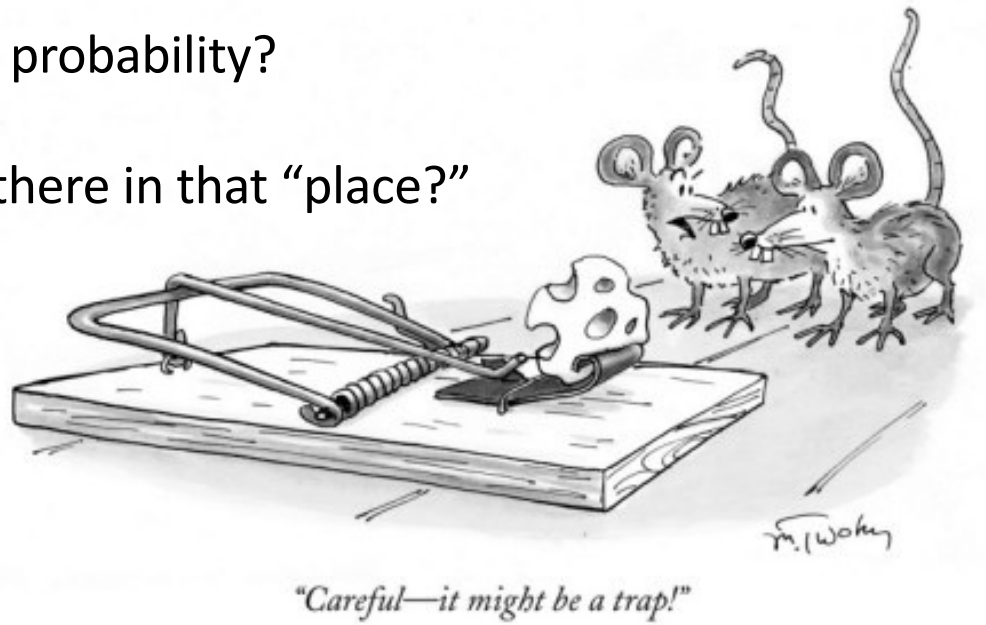


“Careful—it might be a trap!”

THE ESSENCE OF CAPTURE RECAPTURE APPROACHES

Day 1: caught 10 rats, put tags on them
Day 2: caught rats in the same place. 2 had your tags, but 8 didn't

What is the capture probability?
2/10=0.2
How many rats are there in that "place?"
50



"Careful—it might be a trap!"

$$\frac{\boldsymbol{marked\ Day\ 2}}{\boldsymbol{total\ for\ Day2}} = \frac{\boldsymbol{marked\ Day1}}{\boldsymbol{Estimated\ Total}}$$

The **Lincoln–Petersen method (**Petersen–Lincoln index)

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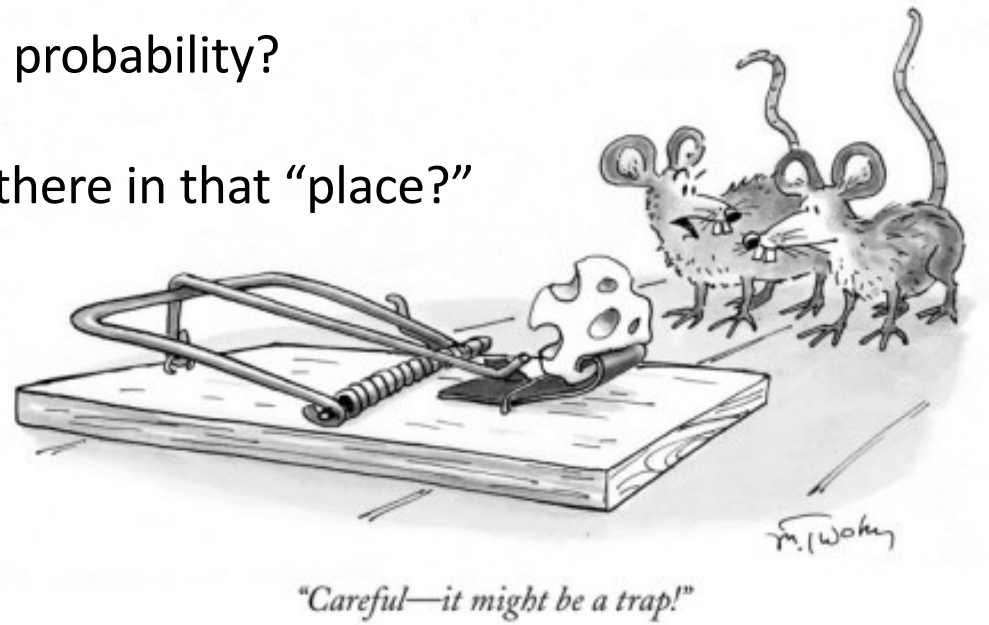
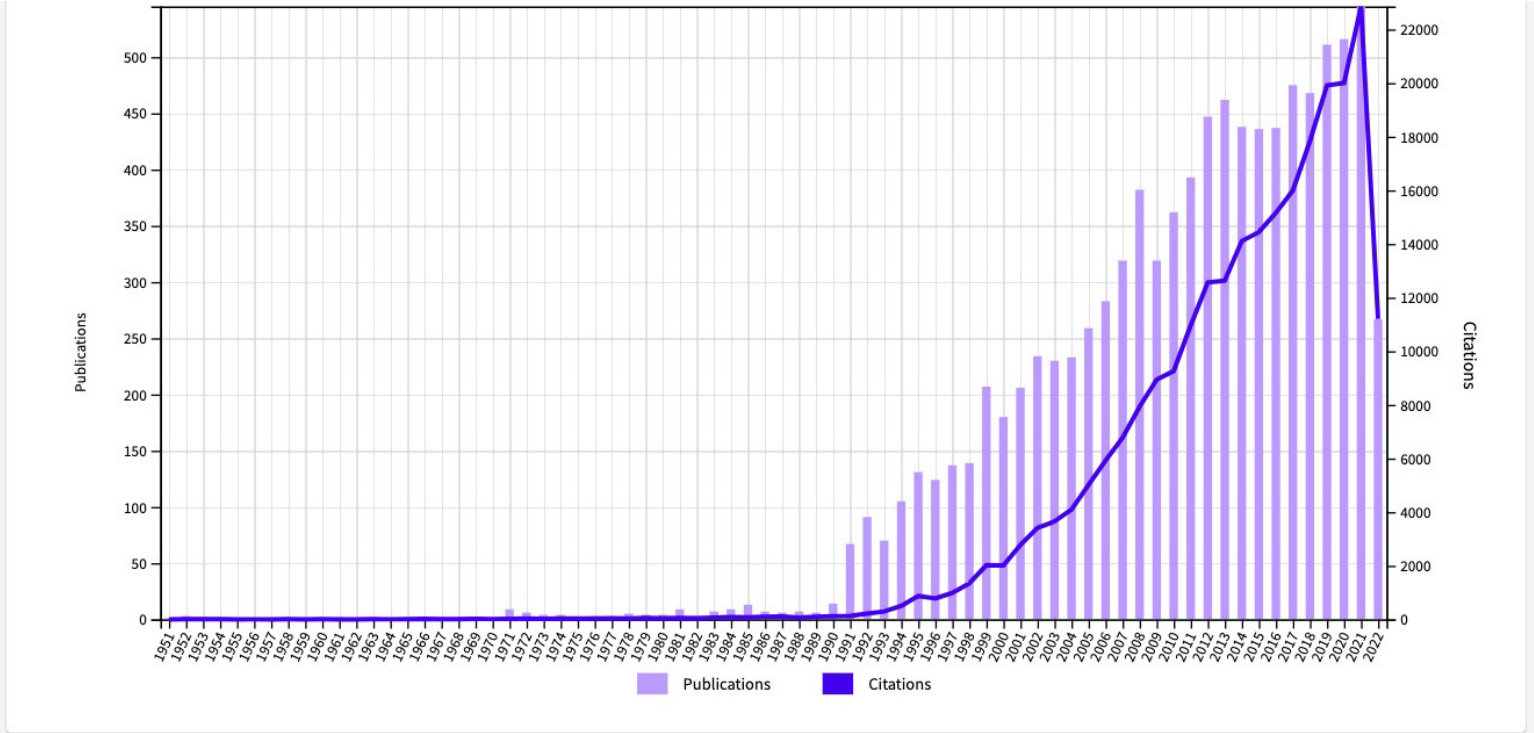


"Careful—it might be a trap!"

Q4 What are the assumptions here made in this approach?

THE GROWTH OF CAPTURE RECAPTURE APPROACHES



9,610 Publications

Sort by: **Citations: highest first** 1 of 193

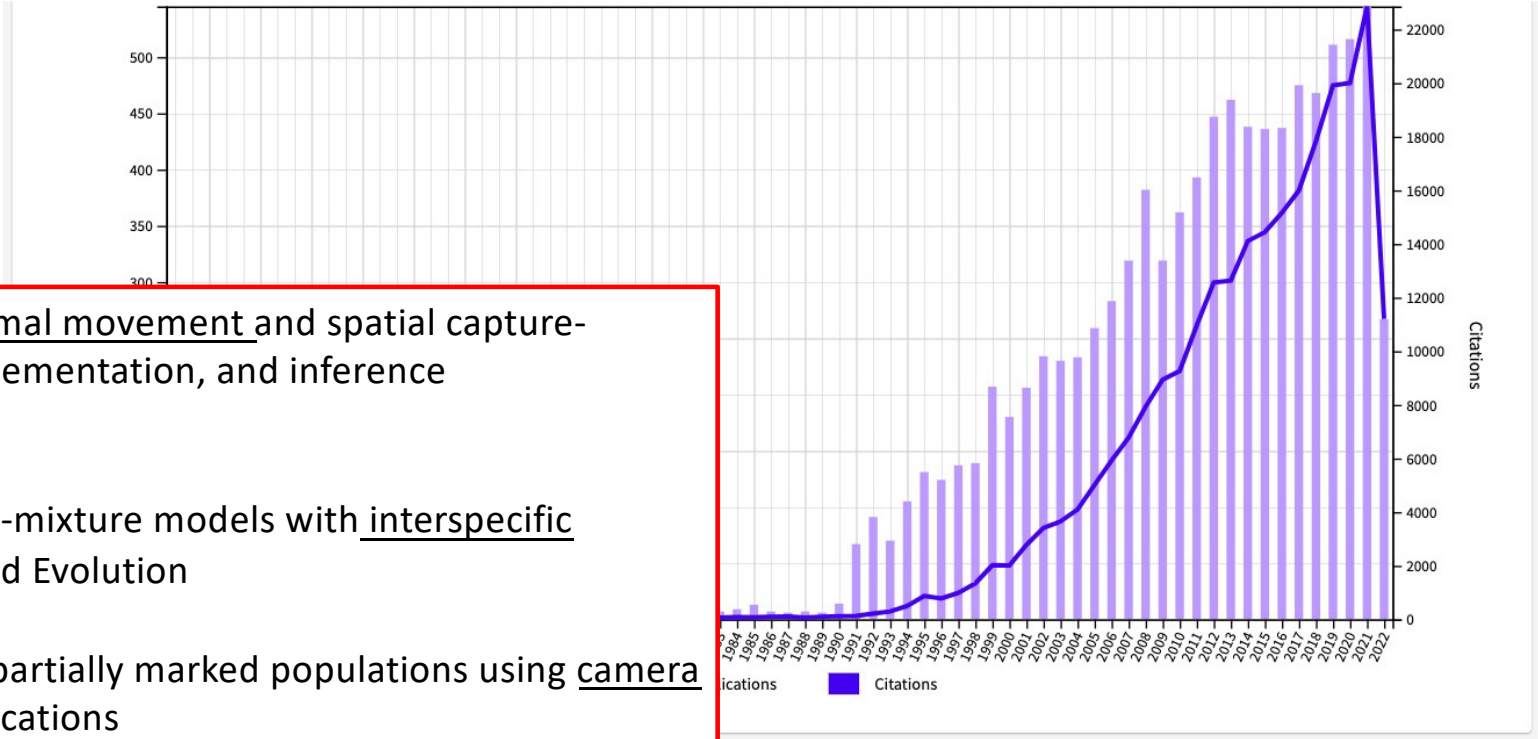
		Citations						
		< Previous year				Next year >	Average per year	Total
		2018	2019	2020	2021	2022		
	Total	17,832	19,916	19,999	22,855	11,203	3,605.1	255,962
1	Program MARK: survival estimation from populations of marked animals White, GC and Burnham, KP 1999 | BIRD STUDY 46 , pp.120-139	291	328	287	265	112	231.71	5,561

THE GROWTH OF CAPTURE RECAPTURE APPROACHES

Gardner et al. 2022 Integrated animal movement and spatial capture-recapture models: Simulation, implementation, and inference Ecology

Zhao et al. 2022 Spatial dynamic N-mixture models with interspecific interactions Methods in Ecology and Evolution

Margenau et al. 2022 Monitoring partially marked populations using camera and telemetry data Ecological applications



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HISTORY OF ESTIMATION TAXONOMIC RICHNESS AND DIVERSIFICATION RATES

Nichols & Pollock 1983 Estimating taxonomic diversity, extinction rates, and speciation rates from fossil data using capture-recapture models. *Paleobiology* 9, 150–163

Foote & Raup 1996 Fossil preservation and the stratigraphic ranges of taxa. *Paleobiology*

Foote 1999/2001 (Boundary crossers method)

Alroy et al. 2001 (sampling standardization)

Connolly and Miller papers 2001-2 using CMR (Connolly is an ecologist)

Foote 2003 (few people use this) – CMR-like, but accounts for orgination and extinction within time interval (but see robust design)

(Liow et al. 2008) My own first capture recapture paleo-paper – I met Nichols in 2006; short course paper with Nichols

Silvestro, Schinitzler & Liow Syst bio 2014 Pyrate model paper (not the software)

Warnock et al. 2020 RevBayes (starting from birth death models but dropping the “relationships”)