The Ins and Outs of Population Ups and Downs

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Population Trends

- When is a decline real?
- When is an outbreak happening?
- When can we open hunting on a species?
The Inference Problem

Population data over time not independent

Regression assumes they are

Null model: slope = 0

test $H_0$: $b = 0$

reject Ho
Inference for Autoregressive Series

A proper null for populations

Stochastic influences multiplicatively accumulate
Null is NOT slope = 0
Logistic model
  Long-term stability
  Fluctuations on short time scale
The Null

\[ N_{t+1} = N_t e^{r_t} \]

\[ r_t = \text{Norm} \left( \mu = r \left( 1 - \frac{N_t}{K} \right), \sigma^2 \right) \]

Bounded random walk (BRW)

Long-term stable but fluctuating
First 100 years of a 10,000 year run of a BRW model using parameters \( K = 1000, r = 0.25, \sigma^2 = 0.005 \).

The model exhibits long-term stability.
Series Length Effect

Distribution of trends by linear regression for all 5 (blue) and 20 (orange) year subsets of the 10,000 year BRW simulation.
Null Implications

For given $\mu$, $\sigma$, $X\%$ of series of length $t$ will show $> d\%$ decline

This is our null expectation, not zero trend.
BBS Test Data

128 species

AL & GA

46 years data
For all routes with statistically significant positive 46-year slope, more and more routes have statistically “0” slope for shorter series (thick line).
Statistical Power

For statistically 0 slope for 46 years, shorter series become more likely to appear positive or negative between 20-30 years, then back to neutral as power is lost with short series.
Metapopulation Effects

Consider a metapopulation

Of $N$ sites sampled, $p$ are occupied at year 0

Only these occupied sites are resampled $t$ years later

Problem: over time, occupied sites revert to the mean occupancy
Metapopulations and Sampling

Panel a shows the change in occupied sites over years, with a solid line representing a steady increase and a dashed line showing a decrease. Panel b displays the number of occupied sites over years with a solid line indicating a decrease and a dashed line showing a more gradual reduction. Panel c illustrates the occupied sites over years with a solid line showing a rapid increase followed by stabilization and a dashed line depicting a slow initial decrease.
Detectability

Consider N sites sampled in year 0, resampled later

Detectability is not high

OR populations fluctuate

Result: apparent decline on resampling
Detectability: multiple surveys reduce apparent decline

Skelly et al. (2003) resurvey of ponds in a reserve in Michigan (solid line) when all original ponds were resurveyed. Simulation (dashed line) of resurveys using detectability of 50%.
Summary

Null model for population time series

BRW model
Implies simple regression misleading
Short series lose power
20 years reasonable length for inference

Metapopulations

Can cause spurious declines if only resample original occupied sites

Detectability issues

Need to resurvey for several years