Assessing Population Trends

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Population Trends

• Trend in abundance or index or vital rate or...
• Observation error and process error
• Statistical education
• Bayesian methods
• Weighted regression
• Power to detect trends
Population Trend

![Population Trend Graph](image-url)
Population Trend
Population Trend
Issues not considered here...

• Issues specific to abundance estimation
  Detectability
  Mark-recapture models for trend

• Alternative models
  Generalised additive models
  Autocorrelation
  Random-walk-with-drift (observation error unknown?)

• Spatial aspects
  "Route regression"
Population Trend

Two sources of error - usually ignored in STAT101
Population Trend

Two sources of error - usually ignored in STAT101
Weighted regression in STAT201? Poorly understood
Model

\[ Y_t = a + bt + e_t \]

\[ V(e_t) = V(\delta_t + \varepsilon_t) \]

\[ = \sigma^2 + v_t \]

\( Y_t \) = simple mean from replicates

\( Y_t \) = derived estimate e.g. mark-recapture

Process error variance

Observation error variance

Y may be on log-scale
Modern Approach

• Bayesian model fitted to all the data
  No need to assume observation error variance known

• Bayesian model fitted to annual estimates
  Assume observation error variance known

• Allows us to focus on specifying model

• Helps us see need for two sources of error

• Future STAT101+
  Basic Bayesian modelling standard
  Classical methods often useful as quick short-cuts
Classical Approach

Weighted Regression

1. Allow for differential precision of the annual estimates

2. Carry out regression using weights

\[ w_t = \frac{1}{\text{var}_t} \]

where \( \text{var}_t \) is "the variance of the estimate in year t"

3. Often implicit that \( \text{var}_t = v_t \) (ignores process error)
Classical Approach

Doing Weighted Regression Properly.

1. Initial value for process error variance: \( \sigma^2 = \text{RMS} - \bar{v} \)
   - \( \text{RMS} \) Residual MS from unweighted regression
   - \( \bar{v} \) Mean observation error variance

2. Carry out weighted regression using weights
   \[
   w_t = \frac{1}{\sigma^2 + v_t} \quad \left( \text{NOT} \quad w_t = \frac{1}{v_t} \right)
   \]

3. Change value of \( \sigma^2 \) until RMS from weighted regression = 1
   NB May need to try \( \sigma^2 < 0 \)
Power Analysis

Link & Hatfield (1990) Ecology

Hatch (2003) Biological Conservation

"A ... question that often arises in monitoring studies concerns the sensitivity of statistical power to varying levels of sampling effort within years... available software is unable to address this question for trend analyses, and serious errors may be committed in attempting to do so."

"Neither MONITOR nor TRENDS models the within- and between-years components of variance independently."
True decline of 5% per year ($\alpha = 0.1$)
Summary

- Estimating population trends (and other contexts)
  Simple (unweighted) regression vs Bayesian methods
  Pitfalls associated with "textbook" weighted regression

- Bayesian methods
  Explicit recognition of different sources of variation
  Automatically estimates uncertainty in $\sigma^2$
  Can be extended to allow for uncertainty in $v_t$

- Use of simple regression (current research)
  Fine when $v_t$ roughly constant
  Better than weighted regression when uncertain about $v_t$
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