Assessing Population Trends

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SEEM5 - Statistics in Climate Change

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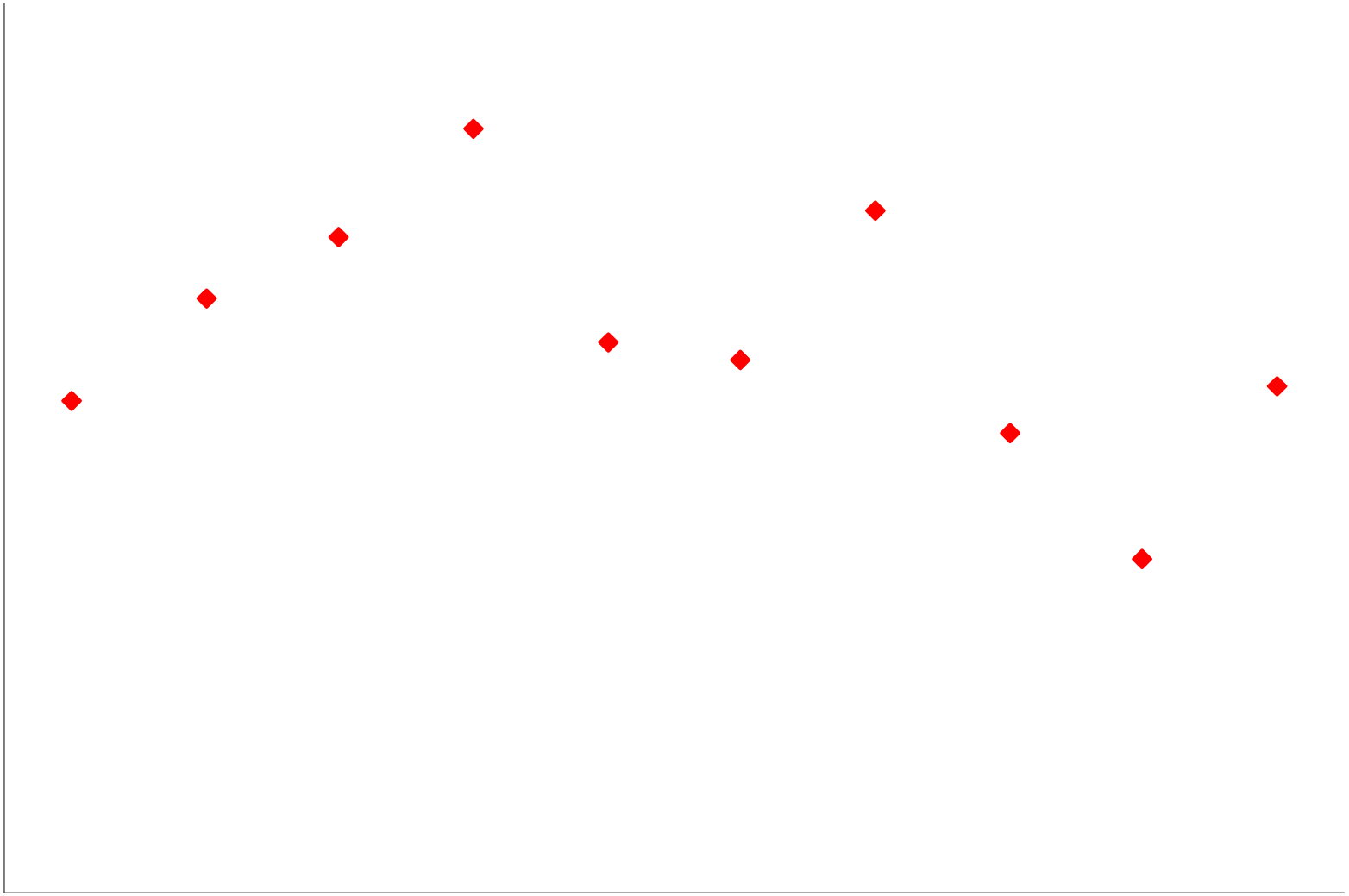
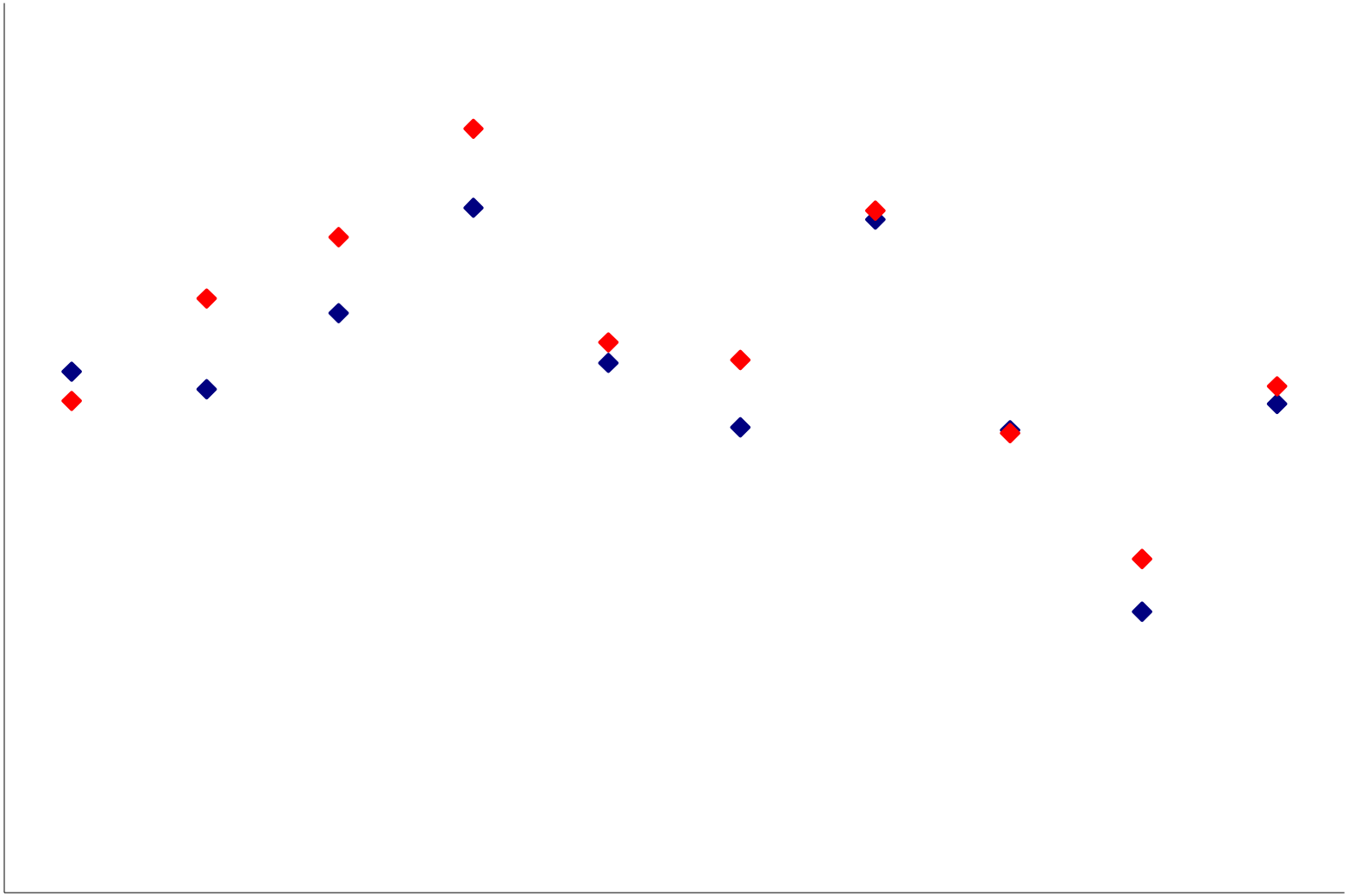
Population Trends

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

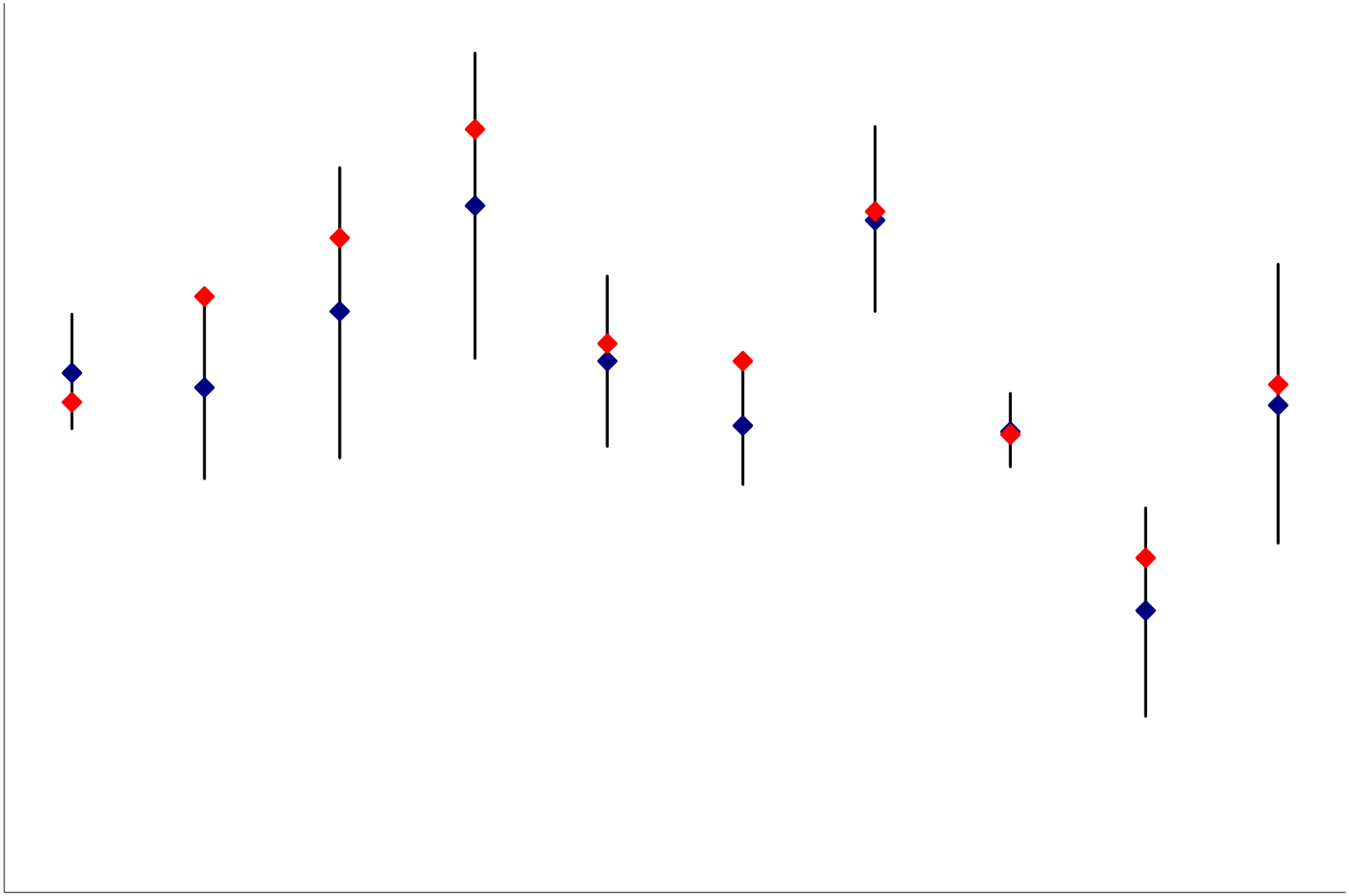
Population Trend



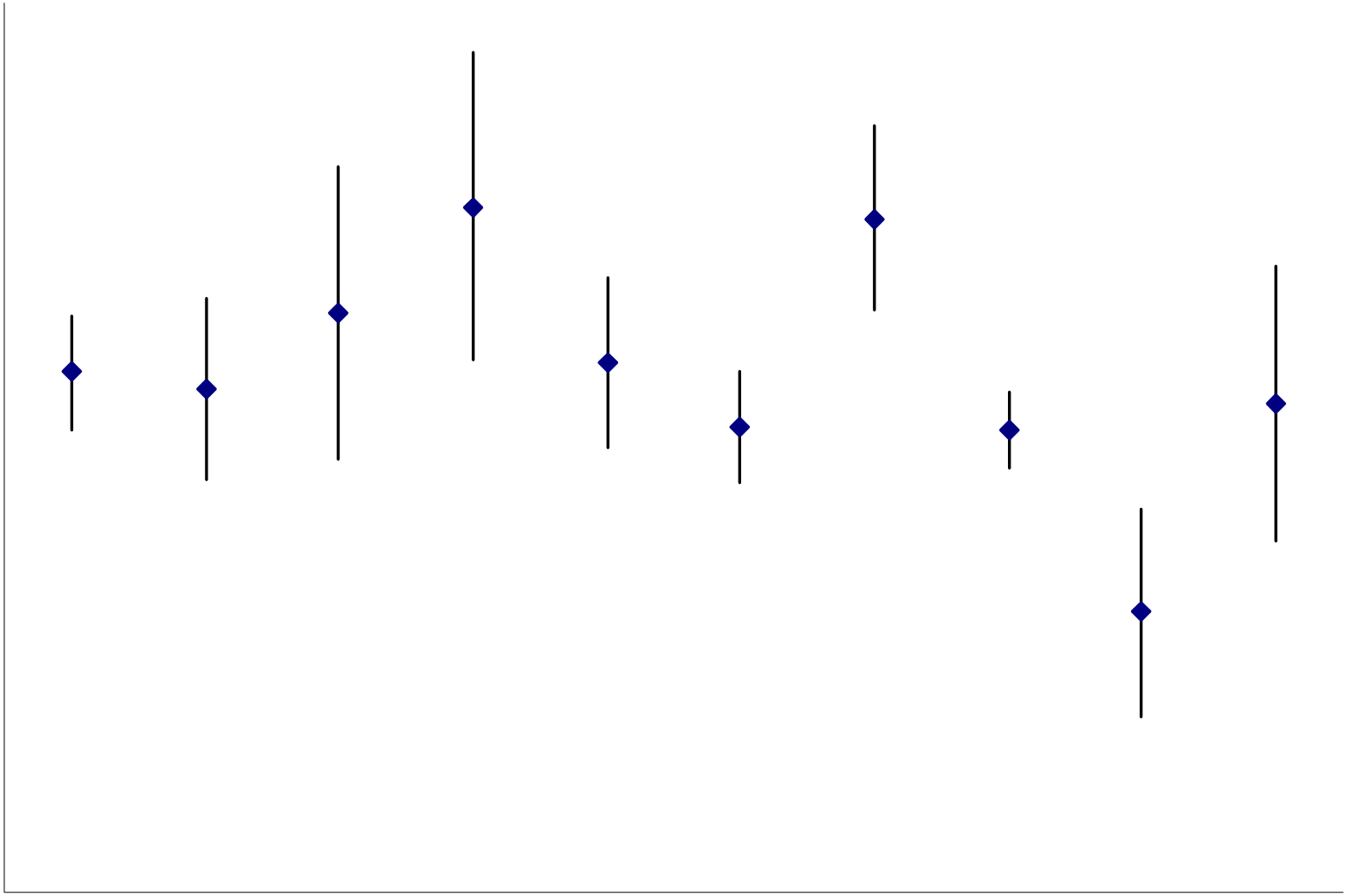
Population Trend



Population Trend



Population Trend



Issues not considered here...

- Issues specific to abundance estimation

  Detectability

  Mark-recapture models for trend

- Alternative models

  Generalised additive models

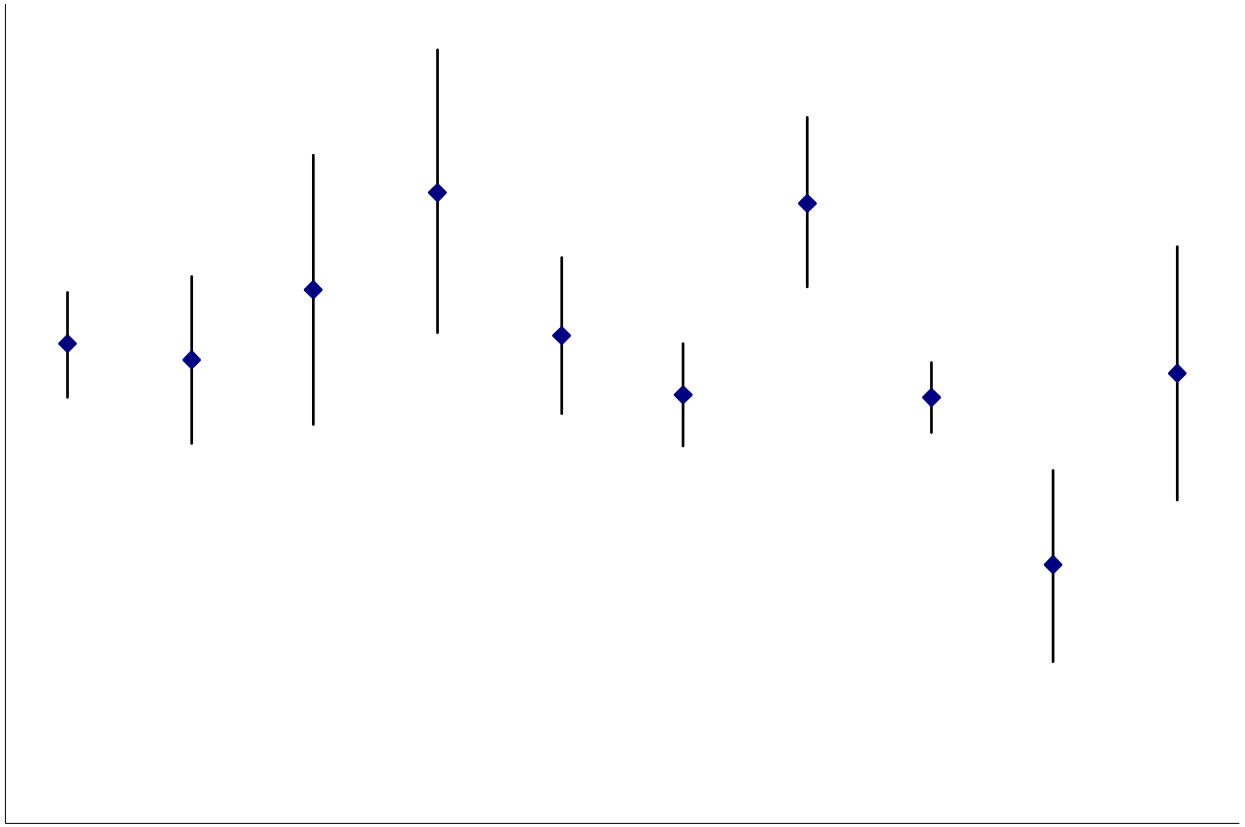
  Autocorrelation

  Random-walk-with-drift (observation error unknown?)

- Spatial aspects

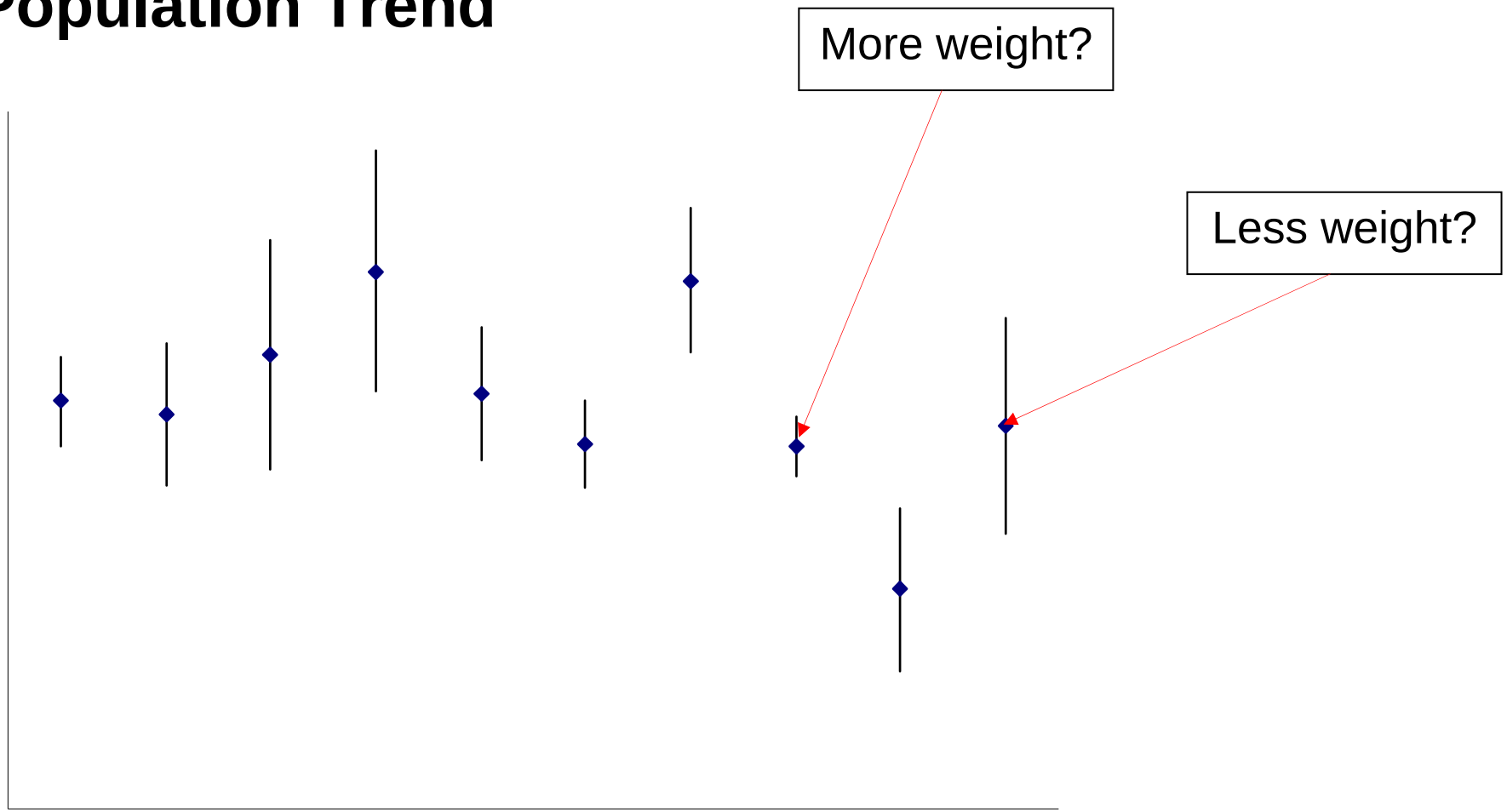
  "Route regression"

Population Trend



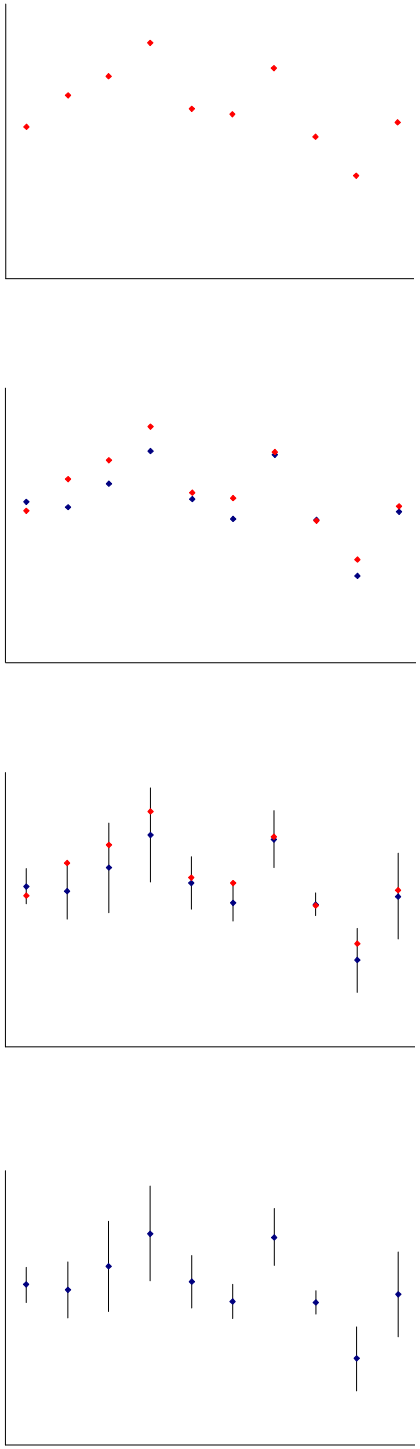
Two sources of error - usually ignored in STAT101

Population Trend



Two sources of error - usually ignored in STAT101

Weighted regression in STAT201? Poorly understood



Model

Y may be on log-scale

$$Y_t = a + bt + e_t$$

$$V(e_t) = V(\delta_t + \varepsilon_t)$$

$$= \sigma^2 + v_t$$

Process error variance

Observation error variance

Y_t = simple mean from replicates

Y_t = derived estimate e.g. mark-recapture

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

$$w_t = \frac{1}{var_t}$$

where var_t is "the variance of the estimate in year t"

3. Often implicit that $var_t = v_t$ (ignores process error)

Classical Approach

Doing Weighted Regression Properly..

1. Initial value for process error variance: $\sigma^2 = \text{RMS} - \bar{v}$

   RMS Residual MS from unweighted regression

   $\bar{v}$ Mean observation error variance

2. Carry out weighted regression using weights

$$w_t = \frac{1}{\sigma^2 + v_t} \qquad \left(\text{NOT} \quad w_t = \frac{1}{v_t} \right)$$

3. Change value of σ^2 until RMS from weighted regression = 1

   NB May need to try $\sigma^2 < 0$

Power Analysis

Gerrodette (1987) Ecology

Link & Hatfield (1990) Ecology

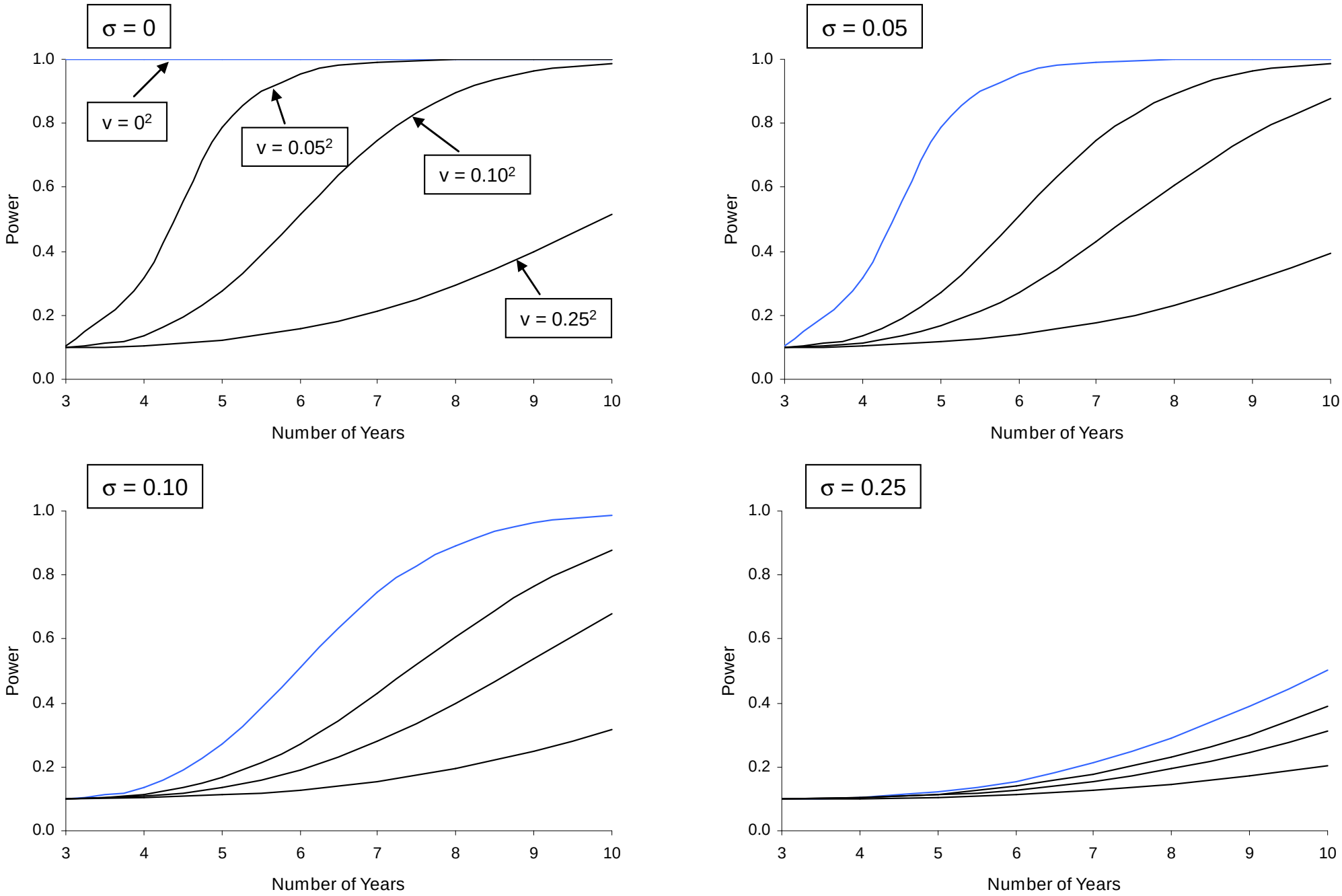
Gerrodette (1991) Ecology

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 not TRENDS models the within- and between-years components of variance independently."

True decline of 5% per year (α = 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 σ^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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