# Matching observations and reality: monitoring under uncertainty in the Serengeti

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## Introduction

Conservation success requires **effective and efficient monitoring** strategies. Monitoring is, however, often inadequate. Survey design and data quality are common problems affecting monitoring schemes worldwide [1].

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Monitoring may be affected by multiple **uncertainties** [2]. For example, **aerial surveys** are often reported to produce underestimates but quantifying biases and prioritizing errors for their minimization is difficult given our limited ability to experiment on the real world.

Using selected antelopes in the Serengeti, we used simulation modelling to investigate: how is monitoring **accuracy** (how close a measure is to the true value) and **precision** (how close repeated measures are to each other) affected by **observation error**?

## Parameters

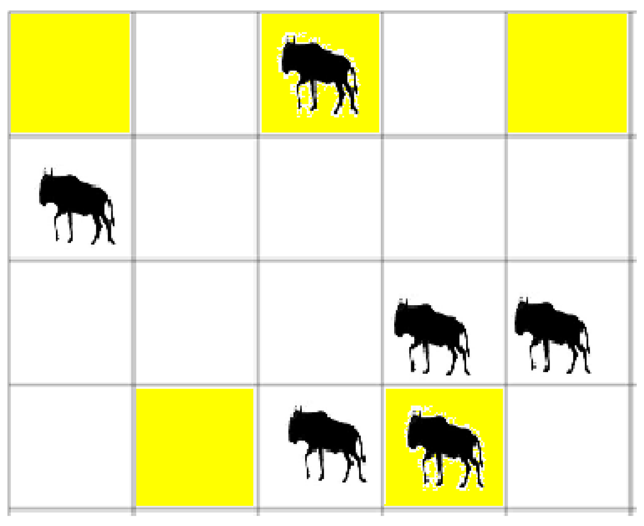
| Parameters (wildebeest monitoring model) | Range |
|---|---|
| <u>Population characteristics</u> | |
| Population size | 200 000 – 2 000 000 |
| Proportion of juveniles (%) | 5 - 35 |
| Aggregation | 0.01 - 2 |
| Spatial autocorrelation | 0.1 - 0.9 |
| <u>Sampling characteristics</u> | |
| Distance between transects (km) | 1-18 |
| Time between photos (seconds) | 5-120 |
| <u>Flight characteristics</u> | |
| Mean flight altitude (m) | Fixed (1200) |
| CV (coefficient of variation) error altitude | 0 - 0.3 |
| Mean flight speed (km/sec) | Fixed (0.06) |
| CV (coefficient of variation) error speed | 0 - 0.3 |
| <u>Observer effects</u> | |
| Minimum error counting juveniles (%) | 0 - 20 |
| Number of animals in a photo for which 50% juveniles are missed | 20 - 50 |
| Mean error counting adults (%) | 0 - 20 |
| CV (coefficient of variation) error counting adults | 0 - 0.5 |

1000 sets of parameter values were generated from uniform distributions (50 replicates each set). Generalised linear models were fitted to scaled variables to explain changes in precision and accuracy.

## Sources of uncertainty

**Process (sampling) error:**
results from the spatial distribution or other characteristics of the population

**Observation error:**
results from uncertainties in the way in which the population is observed (e.g. undercounting)

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## Methods

**A** True state → True abundance

**B** Observed state → Estimated abundance

**C** Analysis

**A) Spatial-explicit model**

Incorporates the effects of population characteristics:

- population size
- proportion of juveniles
- aggregation
- spatial autocorrelation

**B) Observation model**

Incorporates the effects of:

- sampling effort
- undercounting
- observational procedures

**C) Analysis**

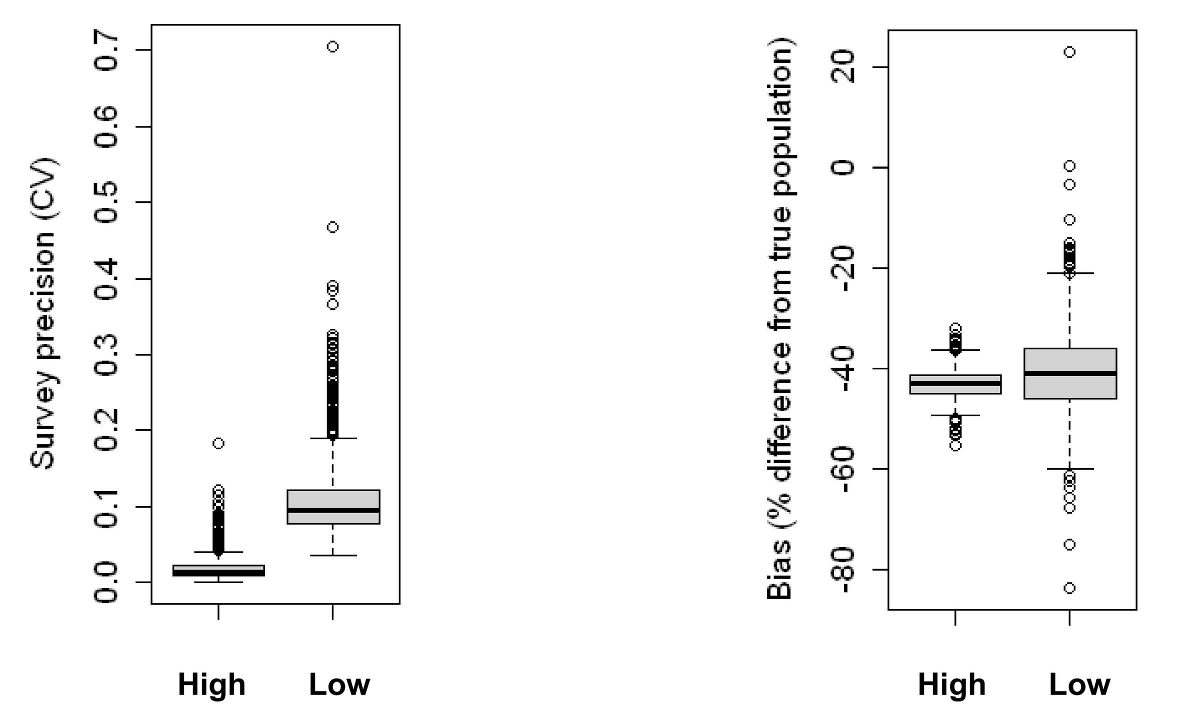
1. Assessment of survey precision (coefficient of variation; CV) and accuracy (bias)

2. Sensitivity analysis to rank drivers of change in precision and accuracy

## Results

**Standardized regression coefficients (β)**
(only parameters with β≥0.3 are shown; *** = P<0.001)

| Model outputs | Aggregation | Spatial autocorrelation | Distance between transects | Mean error counting adults | Population size |
|---|---|---|---|---|---|
| **Survey CV** | -0.42*** | -0.32*** | 0.45*** | | |
| **Bias** | | | | 0.40*** | 0.30*** |




**Distribution of precision and bias for different monitoring budget scenarios**
High or low budget scenarios assume parameters at their best or worst values, respectively. For example, the low budget scenario assumes conducting only a few transects and high counting variability.

## Conclusions

- Importance of addressing **uncertainties** to recognize and minimize errors in monitoring
- **Trade-offs** must be identified and considered in monitoring decisions
- Modelling is a particularly useful tool because it allows **experimentation through simulation**

## Literature

[1] Legg & Nagy (2006) Why most conservation monitoring is, but need not be, a waste of time. *Journal of Environmental Management* 78: 194–199
[2] Harwood & Stokes (2003) Coping with uncertainty in ecological advice: lessons from fisheries. *Trends in Ecology & Evolution* 18: 617-622

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