Managing social-ecological systems under uncertainty: a multidisciplinary approach

Ana Nuno, PhD
University of Exeter, UK
I thought I was interested in uncertainty but now I'm not so sure.
Harvest

Observation

Assessment

Resource users

Implementation

Managers

Observation

Monitors

Natural resources

Implementation uncertainty

Process uncertainty

Measurement uncertainty

Milner-Gulland et al. (2010) *Biology Letters*
Study-area: Serengeti, Tanzania
I – Wildlife monitoring under uncertainty


Observation

Natural resources

How well do we count animals?

Monitors

How does wildlife react to different threats?

Assessment

Are we able to detect change in wildlife abundance when it actually happens?
Questions

1. How do different monitoring budgets translate into data quality (accuracy and precision)?

2. How are different types of error affected by budgetary, observational and ecological conditions?
Types of error

- **Type I errors (α):** rejecting the null hypothesis when it is true

- **Type II errors (β):** failing to detect a difference that is present

- **Shape errors:** misclassifying a trend as linear when it is actually non-linear or vice-versa
1. Operating biological model

Wildebeest

“True” abundance of different species under realistic scenarios of change
2. Observation model
Types of factors

Wildebeest monitoring:

<table>
<thead>
<tr>
<th>Population characteristics</th>
<th>Population size</th>
<th>Proportion of juveniles (%)</th>
<th>Aggregation</th>
<th>Spatial autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling characteristics</td>
<td>Distance between transects (km)</td>
<td>Time between photos (seconds)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight characteristics</td>
<td>Mean flight altitude (m)</td>
<td>CV (coefficient of variation) error altitude</td>
<td>Mean flight speed (km/sec)</td>
<td>CV (coefficient of variation) error speed</td>
</tr>
<tr>
<td>Observer effects</td>
<td>Minimum error counting juveniles (%)</td>
<td>Number of animals in a photo for which 50% juveniles are missed</td>
<td>Mean error counting adults (%)</td>
<td>CV (coefficient of variation) error counting adults</td>
</tr>
</tbody>
</table>
Results: monitoring wildebeest

The likely effect of budget on data quality

“Observed” abundance of different species under realistic scenarios of change

3. Assessment model & Analysis

A: Operating model
  Drivers of change
    Ungulate population dynamics

B: Observation model

C: Assessment model
  True biological trend

D: Analysis
  Observed biological trend
Results

Type II error

- ▲ Impala
- ● Wildebeest

Frequency (years between surveys)
Results

Type II error

High monitoring budgets

Low monitoring budgets

Impala
Wildebeest
Key messages

• To make robust management decisions, we should account for multiple types and sources of uncertainty

• Need to integrate ecological modelling, threat scenarios and costs into decision-theoretic approaches to NRM and conservation

• Our uncertainty mitigation efforts must be focused on the kinds of information which are most valuable
II – Assessing “sensitive” resource use


Harvest

Observation

Resource users

Natural resources

Monitors
Illegal bushmeat hunting
**Illegal hunting in the Serengeti**

**How many?**
8 to 57% hhs

**Who poaches?**
- Ethnic group
- Household size
- Household migration
- Household employment
- Season
- Hunting as source of cash

<table>
<thead>
<tr>
<th>District</th>
<th>Distance from village to protected areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Access to alternative sources of protein and/or income</td>
</tr>
</tbody>
</table>
“715 individuals were asked if they were involved in hunting. Many [84%] chose not to answer” (Campbell et al. 2001)

“deep reluctance among the respondents to talk about bushmeat hunting” (Nyahongo et al. 2009)

“collected data needs to be treated cautiously, because we may have been lacking important information due to fear from respondents” (Mfunda & Røskaft 2010)
How to estimate illegal resource use?

- Law-enforcement records
- Indirect observation
- Forensics
- Direct observation
- Self-reporting
- Direct questioning
- RRT
- Modelling

Specialized questioning techniques

• nominative technique

• randomized response technique

• crosswise, triangular, diagonal and hidden sensitivity models

• bean method

• grouped answer method

• surveys with negative questions

Nuno & St John (in press) *Biological Conservation*
Unmatched-count technique

Treatment

Card 1

Livestock herding
Farming
Trading
Hunting
Teaching

Control

Card 2

Livestock herding
Farming
Trading
Teaching

Dalton et al. (1994) Person. Psychol.
15 villages, Western Serengeti
1192 household interviews
A. Individual characteristics
B. Household characteristics
C. Household participation in hunting
D. Opinion about survey technique
Results I

Non-response rate: <3%

Estimated hunting households (%):
Results II

Model coefficients (± S.E.):
Conclusions I

- poaching remains widespread in the Serengeti

- households hunt both for food and cash all year round

- current alternative sources of income may not be sufficiently attractive to compete with the opportunities provided by hunting
Conclusions II

A new tool for the conservationists' kit?

- Potential for wider application
- Sample size requirements
- Disentangle survey processes from actual effects of interest
III– Conservation implementation under uncertainty

Resource users → Implementation

Harvest

Managers

How does science translate into management decisions and conservation practice?

How to design interventions that account for human behaviour?
Some questions

• How to manage conflict over natural resource management and conservation?

• How to “predict” resource user behaviour in face of changing conditions?
• 25 “stakeholders” (such as retired seamen)
• 561 households
• 174 high school students
• 117 cruise ship tourists
• 87 stay-over tourists
• 10 restaurant managers (ongoing)
Other areas of research

• Combining (and comparing) social and ecological information into integrated modelling frameworks for decision support

• Social monitoring & linking (and predicting) ecological outcomes with robust “social indicators” (e.g. social networks, behaviour, attitudes?)

• Actual (and perceived) value of information for decision-making
Acknowledgements & Questions

Email: a.m.g.nuno@exeter.ac.uk
Twitter: @Ana__Nuno
Website: ananuno.net