Complexity thinking and objectives setting in complex socio-ecological systems

OR

AN ESSAY ON HORRENOMGRAMS

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Context

• Many conservation questions are complex, uncertain and socially nuanced.

• Therefore approaches are needed that embed conservation decision-making in their socio-ecological context.

• Adaptive management is the main approach to decision making under uncertainty
  – Incorporating cultural, economic and social concerns
  – Take into account ecological resilience and adaptive capacity, and uncertainty
  – While still keeping the simplicity required for management interventions to go ahead (Stirzaker et al)
### Why aren’t more people doing adaptive management?

<table>
<thead>
<tr>
<th>SCIENTIFIC</th>
<th>PRACTICAL</th>
<th>PHILOSOPHICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>None or poorly defined hypotheses</td>
<td>Lack of communication between researchers, practitioners, stakeholder groups</td>
<td>Disagreement over what is adaptive management: some elements adaptive / some not (programmatic versus project)</td>
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<td>Hypothesis testing unfeasible in many management scenarios</td>
<td>Urgent time-frames, conflicting responsibilities</td>
<td>Risk aversion; following prescriptions is safer</td>
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<td>Lack of replication make “experiments” inconclusive</td>
<td>Financial / personnel / logistical constraints</td>
<td>Lack of ownership of “experiments”; communication issues, disaffected stakeholders</td>
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<td>Simplistic experiments, versus complex reality</td>
<td>Lack of management / implementation capacity or options</td>
<td>Plurality of perspectives: difficult to define desirable / undesirable outcomes</td>
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<td>Changing environmental conditions, surprises, large infrequent disturbances</td>
<td>Institutional / policy / management inflexibility</td>
<td>Focus on planning not action: learning and discussion do not lead to changes in policy and management</td>
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<td>Lack of monitoring and assessment, therefore response or adaptation is difficult / impossible</td>
<td>Timescales: funding cycles / lifespan of projects</td>
<td>Learning is under-emphasised</td>
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<td>Lack of long-term data means that we don’t know the “normal” or historical range of variability</td>
<td>Lack of personal experience</td>
<td>Process needs leadership and facilitation without prescription</td>
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<td>Extrapolation is risky because of non-linearity / thresholds</td>
<td>Lack of stakeholder engagement</td>
<td>Communication difficulties across disciplines, disciplinary bias, science-policy-practice divide</td>
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“...to create a useful framework that allows one to unlearn reductionist habits while adopting and embedding those more conducive to working in complex systems.”

- Diamond Schematic (Kay et al, 1999)
- Interdisciplinarity (Wolfe et al, 2007)
- New Framework (Gillson, in press)
- Emerging modeling / decision making tools
An adaptive, systems approach to ecosystem management (after Kay et al, 1999)

Develop a Multi-scale (Holarchic/Ecosystem Description)

Develop an Issues Framework

System Identification

SCENARIOS

Which self-organizing entities do we want to encourage?

DESIGN THE CONTEXT
Human and ecological infrastructure

GOVERNANCE
MONITORING
MANAGEMENT

ONGOING ADAPTIVE MANAGEMENT

COLLABORATIVE PROCESS

COMPLEXITY THINKING

SYSTEMS APPROACH

Local Knowledge
Science
Complex Systems Theory

Culture, Values
General Vision
Economic and Political context
Both natural and social sciences are included in a collaborative learning process that seeks to understand local residents needs and value traditional knowledge respecting the concerns of communities in northern Canada (Wolfe et al., 2007).
SANParks
Strategic
Adaptive
Management

MANAGEMENT UNDER UNCERTAINTY

Figure 3.1: Strategic adaptive management (SAM) process

Stakeholder involvement crucial
VISION FOR THE LANDSCAPE
(Pattern, Process, Scale)

Past range of variability

What is the range of ecological possibilities?
(Long-term data, Modeling)

Future Scenarios

Socio-economic context
Governance and policy context
Scientific context

CULTURE
VALUES
LOCAL CONTEXT

VISION FOR THE LANDSCAPE

DEFINE MAIN LANDSCAPE ZONES

Biodiversity
Ecosystem Services
Livelihoods

ENVIRONMENTAL UNCERTAINTY

What are the key drivers?
(Monitoring, experiments, modeling)

DEFINE THRESHOLDS OF POTENTIAL CONCERN

ENVIRONMENTAL UNCERTAINTY

ADAPTIVE MANAGEMENT
(Implementation, monitoring, adaptation, modeling)

Gillson 2015 In Press
Exploring perspectives, combining empirical and qualitative / subjective data

• Methods are needed to explore different perspectives, and to incorporate empirical data with subjective viewpoints and expert opinion,
• Together these combined perspectives can be used to define the conservation visions that underpin management objective setting (Cook et al. 2013).
• E.g. Q methodology, (Sandbrook et al. 2011, Milcu et al. 2014).
• Causal criteria analysis can be used to assess weak or non-quantitative evidence for multiple hypotheses giving insights into complex chains of cause and effect (Norris et al. 2011).
• Bayesian networks are graphical models expressing the probability of the relationships (causal links) between a series of predictor and response variables (Norris et al. 2011, Rumpff et al. 2011).
Bayesian Belief Networks

- Bayesian Belief Networks (BBNs) are graphical models expressing the probability of the relationships (causal links) between a series of predictor and response variables (Norris et al. 2011, Rumpff et al. 2011).

- BBNs provide a structured combination of diverse lines of evidence, and can be used to capture expert knowledge and connect it with empirical data, while explicitly incorporating uncertainty.

- BBNs are particularly suitable for use in adaptive management because they can be developed based on expert knowledge and then probabilities can be updated over time as new evidence from monitoring emerges with each iteration of the adaptive management cycle (Newton et al. 2007, Smith et al. 2013).
Example of a Bayesian Belief Network in Adaptive Management (Rumpff et al 2007)
Example of the use of a Bayesian Belief Network in Evidence Based Conservation (Newton et al 2007)

“BBNs can potentially be web-enabled, offering the possibility of using them as an interface to such internet-based evidence bases. The sequential learning capacity of BBNs could be of particular value in this context, enabling them to be readily updated as new evidence becomes available, and the networks to evolve over time.”

Figure 1. Bayesian Belief Network (BBN) constructed for examining the potential impact of grazing by Sika deer on saltmarsh communities (Case 1, see text). The ellipses (nodes) represent variables, and the arrows represent conditional dependencies between the nodes.
Conclusions

• Complexity thinking, interdisciplinarity, collaborative learning and adaptation are all essential elements of management under uncertainty
• Frameworks and methods are needed that combine different perspectives and improve prediction over time
• These methods are evolving and we are moving towards the capability for web-enabled Bayesian networks that can learn over time as new evidence emerges from the adaptive management cycle
• Possible convergence of Adaptive Management and Evidence-Based Conservation?


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