Integrating Economic Values and Catchment Modelling

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Background

- Modelling tools to support integrated catchment NR management and decision making

  Biophysical modelling (hydrology or ecology)

- Integrated management requires integrated assessment, but... limited integration of biophysical and economic models!
Research objective

Developing an integrated model to assess environmental and economic impacts of catchment management changes in Tasmania, Australia
- Synchronized development of models
- Multi-disciplinary research
- Integration using a Bayesian Network approach
Selection criteria:

- Tasmanian coastal catchments interesting for scientific modelling and socio-economic research

- Catchment management impacting on environmental quality

- Availability of scientific monitoring data

- Presence of environmental values
Integration 1 – Selecting study area

- **George River catchment:**
  - Data available – several WQ studies
  - Considerable socio-economic values (agriculture, forestry, aquaculture, environmental assets, recreation)
  - Concerns about impacts of catchment management on natural resources
Consensus between different natural science disciplines, modellers and economists

1. Which management changes?
2. What variables and processes?
   - Model parsimony
   - Ecological indicators
   - Attributes relevant to policy makers and survey respondents
3. How to describe variables?
   - Scientific precision vs survey load
   - Qualitative vs quantitative levels
Integration 2 – Selecting variables
Integration 2 – Selecting variables

- **Management actions:**
  - Weed removal
  - Stream-bank erosion control
  - Fencing riverside zones
  - Changed land use

- **Environmental assets:**
  - Native riparian vegetation
  - Rare animal and plant species
  - Seagrass area in estuary
Integration 2 – Selecting variables

Management actions

- Weed management
- Engineering works in river
- Fencing
- Changing land use

Environmental attributes

- Rare native species
- Native Riparian Vegetation
- Seagrass area

Sedimentation / erosion
Hydrological processes
Ecological response
Methods = modelling

Hydrological modelling

Ecological modelling of CE attributes

CE study
Modelling 1 – Water Quality

- WQ model based on digital mapping of land use, mapped erosion, soil characteristics, rainfall etc.

**Outputs:**
- mapping of sediment and nutrient loads
- identify most important sources (type and location)
Focus on changes in environmental attributes that are meaningful to ‘non-scientists’: 
- Native riparian vegetation
- Rare native plants and animal species
- Seagrass area
- Literature, expert consultation, NRM observations and WQ modelling

- Determine **lowest and highest level** of attributes under various management scenarios (integrate with WQ model and CE scenarios)

- Estimate **probability** that these levels will occur

- Probabilities as inputs in Bayesian Network model
## Modelling 3 – Economic Values

- **Choice Experiment** to assess value impacts of ecosystem changes in the Georges catchment
- **Attribute levels** based on ecological modelling outputs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Possible range</th>
<th>CE levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native riverside vegetation (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 40</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>40 - 60</td>
<td>50</td>
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<tr>
<td></td>
<td>60 - 70</td>
<td><strong>65</strong></td>
</tr>
<tr>
<td></td>
<td>&gt; 70</td>
<td>75</td>
</tr>
<tr>
<td>Seagrass beds in Georges Bay (ha)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 490</td>
<td>420</td>
</tr>
<tr>
<td></td>
<td>490 - 620</td>
<td>560</td>
</tr>
<tr>
<td></td>
<td>620 - 760</td>
<td><strong>690</strong></td>
</tr>
<tr>
<td></td>
<td>&gt; 760</td>
<td>815</td>
</tr>
<tr>
<td>Rare native animals and plant species (number)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 40</td>
<td>35</td>
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<tr>
<td></td>
<td>&gt; 70</td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>
Analysed sample data using Mixed Logit - Random Effects model

Estimate marginal WTP for change in attribute levels

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Marginal WTP ($/unit)</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrass (ha)</td>
<td>0.11</td>
<td>(0.02 - 0.19)</td>
</tr>
<tr>
<td>Riverside vegetation (km)</td>
<td>3.57</td>
<td>(2.52 – 4.61)</td>
</tr>
<tr>
<td>Rare species (#)</td>
<td>8.42</td>
<td>(7.23 – 9.61)</td>
</tr>
</tbody>
</table>
Integration challenge

- Use probabilistic Bayesian Network to integrate results

- Probability shows the level of uncertainty in data and outputs (by number of states and probability distribution)
Integration challenge

- Use probabilistic **Bayesian Network** to integrate results

- Probability shows the level of uncertainty in data and outputs (by number of states and probability distribution)

<table>
<thead>
<tr>
<th>Native Riverside Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less 40%</td>
</tr>
<tr>
<td>40 to 60%</td>
</tr>
<tr>
<td>60 to 70%</td>
</tr>
<tr>
<td>More 70%</td>
</tr>
</tbody>
</table>

75.5 ± 19
Integration challenge

Linking uncertain environmental outcomes and WTP estimates

Monte Carlo simulations of WQ model

Expert opinion
Conclusion

- Support catchment management by integrated modelling tools
- Biophysical models provide scientific basis for CE
Conclusion

- Challenge to match science and economics:
  - Detail and relevance
  - Ecological indicators and valuation attributes
  - Scientific accuracy and survey comprehension

- Joint uncertainty analyses....
Thank you 😊