Comments from the coal face: implementing models to explore changing ecosystem outcomes

Bethanna Jackson\textsuperscript{1,2}, Bridget Emmett\textsuperscript{2} & the LUCI team
\textsuperscript{1} Victoria University of Wellington, NZ
\textsuperscript{2} Centre for Ecology and Hydrology, UK
A comparative assessment of decision-support tools for ecosystem services quantification and valuation

Kenneth J. Bagstad*, Darius J. Semmens*, Sissel Waage*, Robert Winthrop*
<table>
<thead>
<tr>
<th>Service</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Based on slope, fertility, drainage, aspect, climate</td>
</tr>
<tr>
<td>C stock/emissions</td>
<td>IPCC Tier 1 compatible – based on soil &amp; vegetation</td>
</tr>
<tr>
<td>CH$_4$/N$_2$O emissions</td>
<td>IPCC Tier 1 compatible – soils, veg, stocking rate, fertiliser</td>
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<tr>
<td>Water supply and floods/droughts</td>
<td>Topographical routing of water accounting for storage and infiltration capacity as function of soil &amp; land use.</td>
</tr>
<tr>
<td>Erosion</td>
<td>Slope, curvature, contributing area, land use, soil type</td>
</tr>
<tr>
<td>Sediment delivery</td>
<td>Erosion combined with detailed topographical routing</td>
</tr>
<tr>
<td>Water quality</td>
<td>Export coefficients (land cover, farm type, fertiliser, stocking rate info) combined with water and sediment delivery models</td>
</tr>
<tr>
<td>Habitat Approaches</td>
<td>1) Cost-distance approach: dispersal, fragmentation, connectivity. 2) Identification of priority habitat by biophysical requirements e.g. wet grassland 3) Measures of habitat richness, evenness, patch size etc</td>
</tr>
<tr>
<td>Coast/floodplain inundation risk</td>
<td>Based on topography and input height of storm surge/long term rise etc: surface and groundwater impacts estimated</td>
</tr>
<tr>
<td>Tradeoffs/synergy identification</td>
<td>Various layering options with categorised service maps; e.g. Boolean, conservative, weighted arithmetic, distribution plots</td>
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</tbody>
</table>
**Underlying principles:**

<table>
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<th>Practical</th>
<th>Conceptual</th>
</tr>
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<td>1) Can be run using just 3 <em>nationally</em> available datasets and be enhanced with local data if available</td>
<td>1) Operates at a spatial scale <em>relevant for field and sub-field level management decisions</em></td>
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<td>2) Modular – can embed external models &amp; export aspects to other models</td>
<td>2) “Values” features and potential interventions by area affected, not just area directly modified</td>
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<td>3) Fast running, enabling interactive scenario exploration</td>
<td>3) Addresses spatial tradeoffs &amp; searches for “win-win” solutions</td>
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## Underlying principles:

**Practical**

1. Can be run using just 3 nationally available datasets and be enhanced with local data if available.
2. Modular – can embed external models & export aspects to other models.
3. Fast running, enabling interactive scenario exploration and simultaneous sub-field to national planning.

**Conceptual**

1. Operates at a spatial scale relevant for field and sub-field level management decisions.
2. “Values” features and potential interventions by area affected, not just area directly modified.
3. Addresses spatial tradeoffs & searches for “win-win” solutions.
Importance of landscape organisation

a) Permeable strip near top of slope (“High shelter belt”)
b) Permeable strip near bottom of slope (“Low shelter belt”)
c) Permeable strip against slope (“Shelter belt 90° to contour”)

- Fine resolution detail rarely represented in catchment models
- Issue for prediction – and also for derivation and use of model parameters e.g. hydraulic conductivity, nitrogen export, etc…

Direction of down-slope movement
Mapping Wales (21,000 km²) at 5mx5m scale: ~800 million elements per service

- Carbon emissions
- Nitrate in rivers
- Agricultural use
- Flood mitigation
- Woodland priorities

**Carbon loss/gain**
- High sequestration
- Some sequestration
- Near steady state
- Some emission/loss
- High emission/loss
- Water bodies
Feasibility of global application?

- 1.5 days on 1 PC to run LUCI at 5 by 5m over all of Wales for all services
- **Server enabling speeds this 100-fold**+

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Resolution</th>
<th>Area (sq km)</th>
<th>No. pixels</th>
<th>“Home PC” time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wales</td>
<td>5m x 5m</td>
<td>2.1 x 10⁴</td>
<td>0.84 x 10⁹</td>
<td>1.5 days</td>
</tr>
<tr>
<td>New Zealand</td>
<td>15m x 15m</td>
<td>2.7 x 10⁵</td>
<td>1.2 x 10⁹</td>
<td>2.1 days</td>
</tr>
<tr>
<td>World (SRTM)</td>
<td>90m x 90m</td>
<td>1.5 x 10⁸</td>
<td>18.5 x 10⁹</td>
<td>33 days</td>
</tr>
<tr>
<td>World (ASTER GDEM)</td>
<td>30m x 30m</td>
<td>1.5 x 10⁸</td>
<td>167 x 10⁹</td>
<td>298 days</td>
</tr>
</tbody>
</table>

But won’t make sense everywhere: most mature in NZ and the UK. Applications with “groundtruthing” now starting in the Philipinnes and Australia, and about to start in Samoa and Vietnam.
Evaluating LUCI output e.g. Water quality
Groundtruthing at local scale (Uawa, NZ)

Green (soggy) areas have been drained by farmer. Farmer agrees this is wet, overland flow generating land. Plans to put in further drainage routing off land.

Farmer: “I never realised this was boggy land until my tractor got stuck here two years ago”
Framework naturally considers capacity

Predictions of areas with high agricultural production capability-

Predicted optimal agricultural utilisation
- Very high production capacity
- High production capacity
- Moderate production capacity
- Marginal production capacity
- Negligible production capacity
- Water bodies
- "Urban mapped" soils
And is beginning to account for condition

Red text means I have made some kind of judgement call that needs reviewing. e.g. LCM 2007 recent = <10 years, recent in LUCI needs defining by cover type.
Final points

• “Naively”; easy to link up biophysical outcomes from models with fine resolution to any of the proposed “ecosystem accounting units”

• Should some ecosystem accounting units screen for configuration where they lose spatial connections (e.g. reporting against land cover, other “point” information) to avoid perverse outcomes?

• “Origin” of service entering spatial system may not be the best start point or boundary

• We have a system that already considers condition and capacity naturally; and can report in any unit. We and other groups are already formalising this conceptually; while also looking to this group and others to evolve for multiple needs going forward

• Consider what is needed for data and models to not only support countries providing ecosystem accounts, but also understand how different futures might change those accounts (scenario reporting)