Land Use and Sustainability

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Essential Message

• Move beyond “traditional” driver research before land change science is surpassed by other global environmental change initiatives and orientations addressing CHES consequences.

• Critical driver-oriented research remaining is aggregate, comparative, or synthesis in kind requiring systematic-quantitative exploration more so than more remote sensing.
  – Does not negate important monitoring needs.
Example: Incomplete Past Challenge

• Systematic assessment of drivers by spatio-temporal scale
  – How consistent are drivers by these scales?
  – Do areal variations in outcome reflect consistent human-environment conditions?
  – Do these conditions reflect interplay of processes operating at different scales.

• Can be addressed via secondary research activities
Themes & Issues Underway Linking Land Change Science to Sustainability

- Coupled human-environment systems **beyond proximate linkages & with attention to issues of longer term consequences** → labeled sustainability, vulnerability, resilience, tradeoff assessment

1. Conditions of “rural” (?) economy
2. Environmental feedbacks on CHES
3. Tradeoffs ecosystem services & human outcomes
4. Spatial dimension #3
Land Change for Sustainability #1

• Move from land managing unit (household or farm) holding national-regional socioeconomic context constant to *quantitative assessments of conditions of & change in area/regional economy*

• Treat structural changes in rural economy linked to
  – [A] local urban-hinterland dynamics
  – [B] national-regional policies
  – [C] economic globalization
A. Urban Hinterlands

• Direct
  – Classic hinterland development = sustained or > land change as rural production required for urban areas

• Indirect
  – Loss of prime lands to urbanization = expansion of agr & forest loss elsewhere

DeFries et al. 2010 *Nat. Geosci.*
Linear regression & regression tree

Farmland lost Pearl River Delta, 1990-96
B. National-Regional Policies

- Changes in land use policy → major shifts in land cover
- Nonfarm rural sector remittances → same
- Diversify portfolios → same

Rueda 2010: Regional Environmental Science

Schmook + Radel. 2008 Human Ecology
C. Economic Globalization

All recent forest transition countries:

- Additional global land use change embodied in their trade (i.e., net displacement) offsets 22% of their total reforested area
- Total net displacement increasing to >50% in 2003-07
- What are implications for REDD regarding displacement & “virtual” wood

*Legend for net displacement and land use*
- Total net displacement (Mha)
- Agricultural area change (base = 1961) (Mha)
- Forest area change (variable base year) (Mha)

*Meyfroidt, Rudel, Lambin, PNAS, 2011*
Land Change for Sustainability #2

Improve understanding of **environmental feedbacks** on land use (as opposed to mainly land use impacts on ecosystem) & land managers responses

Table 1. Atmospheric deposition of phosphorus as a function of canopy cover and forest age

<table>
<thead>
<tr>
<th>Cover</th>
<th>[P], μg/liter</th>
<th>P input per event, g/ha</th>
<th>Cumulative P input, g/ha per month*</th>
<th>Estimated wet season P inputs, kg/ha†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open field</td>
<td>24 ± 5a</td>
<td>4.2 ± 0.5a</td>
<td>43</td>
<td>0.26</td>
</tr>
<tr>
<td>4-yr-old forest</td>
<td>40 ± 5b</td>
<td>6.5 ± 0.5b</td>
<td>72</td>
<td>0.43</td>
</tr>
<tr>
<td>20-yr-old forest</td>
<td>59 ± 6c</td>
<td>11.8 ± 1.3c</td>
<td>119</td>
<td>0.71</td>
</tr>
<tr>
<td>Mature forest</td>
<td>65 ± 6d</td>
<td>12.3 ± 1.0c</td>
<td>134</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Mean ± SE. Letters a–c indicate significant differences.
*For the period June 2 to July 1, 2006.
†Cumulative P Input × 6 (average no. of rainy months).

Lawrence et al., PNAS 2007, 104 – P limiting nutrient & reduced with loss in forest cover

Schneider & Fernando, Biotropica 2010, 42 – invasive bracken follows multi-burned parcels

FIGURE 3. Total land affected by bracken fern from 1989 to 2005 from LMM results.
Land Change for Sustainability #3

- Link multi-ecosystem service tradeoffs, especially beyond provisioning services, with human outcomes

Nelson et al. *Front Ecol Environ* 2009, 7 – to econ. value

Bennett et al. *Ecol Letters* 2009, 12 – multiple services bundled
Land Change for Sustainability #4

- Accounting for kind, amount, shape, pattern of land-use/cover + spatial dynamics – on ecosystems, services, and human outcomes

**Local pattern A**

- PD, ED, LSI ↑
- Forest structure ↑
- Biomass ↑
- Carbon ↑
- Biodiversity ↑
- P Capture ↑
- Bracken fern ↓
- Evapotrans. ↑
- Farm income ↓
- Degrad. fram land. ↑
- Req. off farm income ↑

**Local pattern A**

- Biodiversity ↓
- Habitat restriction ↓
- Precipitation ↓?
- Ecotourism ↓
- Farm Yields ↓

**Local pattern B**

- PD, ED, LSI ↓
- Forest structure ↓
- Biomass ↓
- Carbon ↓
- Biodiversity ↓
- P Capture ↓
- Bracken fern ↑
- Evapotrans. ↓
- Farm income ↑
- Degrad. Farm land ↓
- Req. off farm income ↓

*Pattern and scalar interactions matter and must be treated more concretely with human outcomes*

• OF COURSE  Sustained monitoring + improvements thereof for effective evaluation of REDD and so on

• BUT  global environmental change research communities are addressing sustainability, vulnerability, & resilience themes—Which require attention to the challenges posted here

LCLUC SHOULD NOT BE LEFT BEHIND BY AAAS, NAS, ICSU, AND INDEPENDENT EFFORTS, e.g.,

SUSTAINABILITY SCIENCE
DIVERSITAS
RESILIENCE
PROGRAMME ON ECOSYSTEM CHANGE & SOCIETY

WHICH INCREASINGLY MOVE BEYOND DRIVERS TO ADDRESS CHES CONSEQUENCES, WITH REMOTE SENSING AS ITS BASE