Measuring and monitoring the flow of forest ecosystem services

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Fifth Trondheim Conference on Biodiversity
31 October 2007
Context

- Background and justification: why assessing the flow of ecosystem services

- Major links between land use and service flow in tropical forested landscapes
  - water and pollination as examples

- Implications for designing and monitoring “compensation and reward schemes”

- Conclusions
Typology of ecosystem services

**Provisioning:** food, timber, fuelwood...

**Cultural:** recreation, spiritual reflection, biodiversity...

**Regulating:** pest control, pollination, nutrient cycling, water filtration...
Compensation and reward schemes are becoming prominent

- Increased economic demand for ecosystem goods and services
- Search for alternative sources of conservation finance
- Corporate investment in environmental assets
- Changes in natural resource governance
Ecosystem service beneficiary

Ecosystem service intermediary

Ecosystem service steward

Ecosystem flow
- crop yield via insect pollination
- sediment yield
- rate of C fixation

Extraction, management, conservation

A conceptual framework
Justification

ISI Web of Science (accessed on Sept. 2007)

# entries ≤ 5 yr

"valuation ecosystem services"  100
"loss ecosystem services"  105
"measuring ecosystem services"  21
"traditional knowledge ecosystem services"  7
“Specific data gaps that posed serious constraints in the Millennium Assessment analysis include the lack of...systematic information on stocks, flows, and economic values of many ecosystem services...” (Carpenter et al. 2006)

“...at the core is the poor characterization of the flow of services in the necessary biophysical and economic terms at the local and regional scales most useful to decision makers” (Chan et al. 2006)

“...how can we better define and measure the services being paid for?” (Scherr et al. 2007)
Forests and water flow

“Evidence of the delivery of watershed services has proved elusive. In many schemes the reported impacts on water flow are based on the views of users, local people or the scheme’s administrators rather than on site measurements and modeling of land use and water relationships”

(Porras and Grieg-Gran 2007)
Why is measuring flow apparently disregarded?

- Most compensation schemes for watershed services are supply-led (no real need to measure or else to get involved)
- Compensations are not made directly for the provision of watershed services (little incentive to measure any effect)
- Schemes are largely implemented on the base of myths and untested perceptions (why measure if we know the effect?)
Primary lowland forest

Montane cloud forest

No forest

Planted forest
<table>
<thead>
<tr>
<th>Conventional wisdom</th>
<th>Scientific evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forests increase rainfall/absence reduces it</td>
<td>Unlikely except for very, very large areas; likely for “cloud forests” (varying magnitude)</td>
</tr>
<tr>
<td>Cutting of forests dries up water supplies</td>
<td>Cutting increases total water yield</td>
</tr>
<tr>
<td>Forests increase runoff</td>
<td>Decrease runoff (probable exceptions: very old planted forests and “cloud forests”)</td>
</tr>
<tr>
<td>Reforestation increase rainfall</td>
<td>No evidence</td>
</tr>
<tr>
<td>Reforestation causes rivers to flow again</td>
<td>In the short term ((\leq 30) yr) usually will not happen</td>
</tr>
<tr>
<td>Forests improve water quality</td>
<td>Likely; for natural and planted</td>
</tr>
</tbody>
</table>

Calder (2005), Bruijnzeel et al. (2005)
Two examples
Beneficiaries in three countries (Costa Rica, Honduras, Nicaragua) involved in compensation schemes for watershed services

In spite of differences in socio-economic status beneficiaries shared a number of perceptions
  - enhanced forest cover leads to better water availability and quality
  - water provision is the most important benefit from forests

Most beneficiaries were not aware of being involved in current schemes

Technical studies did not play a significant role in the design

Kosoy et al. (2007)
Los Negros Valley, Bolivia

- Water levels dropping—clouds ever present in upstream montane forests
  - downstream farmers believed forest protection and water supplies were linked

- In-kind payments protect forest from cutting

- Beneficiaries reward upstream stewards for a service not well assessed—no baseline flow data
  - scheme designed to earn local will and upstream-downstream mutual trust
  - currently implementing paired catchment monitoring (forested, non-forested)

Asquith et al. (2007)
Implications

- To measure or not? Lack of baseline data probably not critical initially yet informed links between land use and water flows may be needed for long-term sustainability
  - mismatches between public perceptions and reality may lead to “beneficiary dissatisfaction”

- Focusing on water availability by expanding forest cover or reforesting degraded lands may not always deliver expected benefits—need for detailed site assessments
  - chances of success likely higher when tackling water quality

- (Bottom up) monitoring potentially critical
  - measuring the magnitude of dry-season water flow gains can have implications for “willingness to compensate”

- Consider participatory “rapid hydrological appraisals”
Animal pollination
Global importance

- 87 crops (35% of global crop production) depend on animal pollination in varying degrees.

- Declines in yield when distant from natural/semi-natural habitat.

Klein et al. 2006
Measuring the flow of pollination services

- In tropical forested landscapes, emerging evidence links extent of habitat modification and crop production.

- Relatively easy: changes in fruit or seed yield ("fruit/seed set") with and without (or few) naturally occurring pollinators.

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Economic value of tropical forest to coffee production

Taylor H. Ricketts*, Gretchen C. Daily†, Paul R. Ehrlich†, and Charles D. Michener†

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Services performed by the ecosystem: forest remnants influence agricultural cultures’ pollination and production

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Proximity to rainforest enhances pollination and fruit set in orchards

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Edge effects on flower-visiting insects in grapefruit plantations bordering premontane subtropical forest

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Measuring the flow of pollination services

important to take into account...

- “Initial” fruit set from “harvestable” fruit set to avoid overestimating the importance of the service (post-fertilization “fruit abortion”)

- Degree of dependence for animal pollinators, need for cross pollination, and amount of external inputs used (e.g. water, fertilizer)

- Site or else geographic differences on the effect of insect pollination on production
  - forest-crop yield effects higher for Indonesian and Central American coffee than Ecuadorian coffee (Bos et al. 2007)
Implications

- More localized in scale and extent than e.g. water provision → compensation schemes only for maintaining forest-based pollinators are rare

- Yet quantifying the area requirements of pollination services can inform decision making for assessing flow of multiple services ("bundling")
Implications

“crop pollination zones” in heavily fragmented production landscapes, Madagascar

Forest fragments

With provision of animal pollination

Bodin et al. 2006
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- If the ecosystem services paradigm is to make effective contributions to conservation and human well-being, compensation and reward schemes may have to:
  - rely less on perceptions and untested assumptions on biophysical flows
  - rely less on supply-led and more on demand-driven flows
  - implement cost effective approaches for monitoring

- Ecosystem flows are dynamic in space and time
  - schemes as ongoing experiments
  - distinguish natural from human-induced variation

- No need to reinvent the wheel
  - knowledge and tools to measure and monitor biophysical flows available
Thank you