Conceptualizing ecosystem service supply, demand, and flows in support of climate change adaptation

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Climate change adaptation & ecosystem services

• Mapping ecosystem service flows: why and how?

• 3 case studies – likely climate change & population growth impacts on ecosystem service supply, demand, flows

• Implications for ecosystem service valuation & resilience
ES & protected areas: cross-boundary flows & landscape-scale management

Palomo et al. in press

Bagstad et al. in press
Why measure ES flows?

• Ecosystem services have a supply & demand side, not always co-located: time & space matter (Syrbe & Walz 2012, Bagstad et al. in press)

• Distinguish *actual* ES provision, use, value rather than just *theoretical/in situ* values

• Account for cross-boundary impacts
  – Private lands -> protected areas
  – Benefits provided from protected areas to adjacent lands
ARIES: A web-based ES analysis tool

Interface through **web browser** *(www.ariesonline.org)*

**Probabilistic models** carry & report uncertainty estimates, work in regions with incomplete data.

Accounts for **spatial flows of ES** from provision to beneficiaries.

**Modeling system** linking database of spatial data & biophysical/socioeconomic models.

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**INTEGRATED ASSESSMENT**
- **AESTHETICS: OPEN SPACE PROXIMITY**
- **AESTHETICS: VIEWSHEDS**
- **CARBON SEQUESTRATION AND STORAGE**
- **COASTAL FLOOD REGULATION**
- **SUBSISTENCE FISHERIES**
- **FLOOD REGULATION**
  - Lives at risk
  - Estimation of lives saved by flood regulation
  - Public assets
  - Avoided cost to public assets from natural regulation
  - Industrial property
  - Avoided cost to industry from natural flood regulation
  - Farms in floodplains
  - Farm damage avoided by natural flood regulation

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Case study :: Region of interest

Total area: 5973.6 km². Covered by models: 100%
Social values mapping

• Value types assigned to places (Brown & Reed 2000 & subsequent work, incl. PPGIS)
• Survey respondents allocate 100 dollars/points across value types and situate on a map
• Social Values for Ecosystem Services (SolVES) tool (Sherrouse et al. 2011)
  – National Forests in Colorado & Wyoming
  – Coastal & marine areas in Australia, California, U.S. Gulf and Atlantic Coasts
  – Potential to construct & test predictive models (value transfer)
Both biophysical models & social surveys are needed

<table>
<thead>
<tr>
<th>Public perceptions of value (mapped using SolVES)</th>
<th>Biophysical ecosystem service delivery (mapped using ARIES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High social values</td>
<td>High ES delivery</td>
</tr>
<tr>
<td></td>
<td>Low ES delivery</td>
</tr>
<tr>
<td>High support for ES-based management (if social values &amp; ES delivery are compatible) OR potential conflict between ES-based management &amp; traditional uses (if social values &amp; ES delivery are not complimentary)</td>
<td>High support for traditional uses; cases where biophysical modeling alone is inadequate to map value</td>
</tr>
<tr>
<td>Low social values</td>
<td>Public outreach needed to build support for ES-based management (e.g., for watershed protection programs)</td>
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### Biophysical models & social surveys

<table>
<thead>
<tr>
<th></th>
<th>Aesthetic value</th>
<th>Biodiversity value</th>
<th>Life-sustaining value</th>
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<tbody>
<tr>
<td>Scenic views</td>
<td>0.1915</td>
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<tr>
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</tr>
<tr>
<td>Carbon storage</td>
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</tr>
<tr>
<td>Sediment sources</td>
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</tr>
<tr>
<td>Water supply</td>
<td></td>
<td></td>
<td>(tbd)</td>
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<tr>
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Life-sustaining value (top), Sediment sinks (bottom)
Social-ecological hotspots mapping
Case studies & climate-change impacts

San Pedro Riparian National Conservation Area (BLM; riparian water needs)

Pike-San Isabel National Forest (FS; fire impacts & downstream water supply)

Cape Lookout National Seashore (NPS; sea level rise)
Coastal NC: sea-level rise

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<td>↑</td>
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<tr>
<td>Recreation</td>
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Southeast AZ: riparian water needs

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## Southern Rockies: fire impacts & downstream water supply

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Summary

- ↓ ES supply, ↑ ES demand: 5/12 cases
- ↓ ES supply, ? ES demand change: 1/12 cases
- ? change to ES supply, ↑ ES demand: 6/12 cases
- Greater uncertainty about future ES supply in arid regions (future climate impacts are more uncertain)
Climate change & ES values

- Population growth = more beneficiaries; uncertain climate = more demand (esp. for regulating services)
  - Results in GREATER ES VALUE
- Higher ES demand and use -> greater potential ecosystem degradation
- Reducing demand for ES & stress on ecosystems
  - Adaptation
  - Technical substitutes (where appropriate)
  - Ecosystem management
  - Demand-side management (pricing externalities)
What’s our goal?

Region III
Critical: perfectly inelastic demand

Region II
Important: inelastic demand

Region I
Valuable: elastic demand

Demand curve for natural capital

Farley 2008
What’s our goal?

- ↑ value of ES (higher demand, rarer ecosystems); potentially ↓ resilience
  or
- ↑ or ↔ ecological & social resilience?