Ecosystem Services: Provision, Value & Policy

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Introduction

- Ecosystems provide a wide array of goods and services of value to people
- Human actions affect ecosystems and the services they provide
- The provision of ecosystem services often is not factored into important decisions that affect ecosystems
- Distortions in decision-making damage the provision of ecosystem services making human society and the environment poorer
Introduction

• How can we “mainstream” ecosystem services?
  – Bring the value of ecosystem services into the everyday decisions of business, government and individuals
Three main tasks

1. Understanding the **PROVISION**
2. Understanding the **VALUE**
3. Create incentives for sustainable provision (**POLICY**)
A research agenda for ecosystem services

- (1) Incentives
- (2) Actions
- (3) Non-anthropocentric approaches
- (4) Ecological production functions
- (5) Biophysical tradeoffs
- (6) Valuation
- (7) Economic efficiency

Other considerations

Policy decisions

Decision by firms and individuals

Ecosystem services

Ecosystems

Benefits and costs

The Natural Capital Project: Mainstreaming ecosystem services
“InVEST”
Integrated Valuation of Ecosystem Services and Tradeoffs

http://www.naturalcapitalproject.org/InVEST.html
Modeling multiple ecosystem services and tradeoffs at landscape scales

Multiple services and scenarios

- Three scenarios of land use / land cover change for the Willamette Basin 1990 – 2050
  - Plan trend
  - Development
  - Conservation
Projected land use change in 2050 under the three scenarios

2050 Plan Trend

1990

2050 Conservation

2050 Development
Multiple services and scenarios

• Multiple services and biodiversity
  – Water quality (phosphorous)
  – Flooding reduction (storm peak)
  – Soil conservation (sediment retention)
  – Climate stabilization (carbon sequestration)
  – Biodiversity (species conservation)
  – Market returns (crop production, timber harvest and housing values)
Outputs through time

Water Quality

1 / Relative Ann. Discharge of Dissolved Phosphorus

1 / Relative Ann. Rate of Soil Erosion in Metric Tons

Carbon Sequestration

Metric Tons

Biodiversity

Countryside SAR

Market Value

Constant Year 2000 Dollars

Plan Trend
Development
Conservation
Ranking of scenarios depends on set of ecosystem services considered
Ranking of scenarios depends on set of ecosystem services considered

![Graph showing the relationship between Net present market value of 1990–2050 commodity production and Countryside SAR score in 2050. The graph illustrates how different sets of ecosystem services (Agricultural, timber, and rural-residential commodities vs. All commodities and carbon sequestration) affect the ranking of scenarios.]
The Impact of Land Use Change on Ecosystem Services, Biodiversity and Returns to Landowners: A Case Study in the State of Minnesota

Polasky et al. Forthcoming. *Environmental and Resource Economics*
Introduction

• Compare the impact on ecosystem services & biodiversity from:
  – Actual land use change from 1992-2001
  – Alternative land use change scenarios
Land use scenarios

• Use National Land Cover Database (NCLD) for 1992 to 2001 for data on actual land use change in Minnesota

• Alternative land use scenarios:
  – No agricultural expansion
  – No urban expansion
  – Agricultural expansion into highly productive soils
  – Forestry expansion into highly productive forest parcels
  – Conservation: low productivity ag land and ag land within a 100 m buffer of waterways in MN River watershed were converted to pre-settlement vegetation
# Land use change 1992 to 2001

## Table 1: Baseline 1992 to 2001 LULC Change

<table>
<thead>
<tr>
<th>From...</th>
<th>Agriculture</th>
<th>Barren</th>
<th>Forest</th>
<th>Grassland / Shrub</th>
<th>Open Water</th>
<th>Urban</th>
<th>Wetlands</th>
<th>1992 Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Acres</td>
<td>Agriculture</td>
<td>24,120,804</td>
<td>2,021</td>
<td>97,638</td>
<td>32,365</td>
<td>86,360</td>
<td>43,362</td>
<td>110,464</td>
</tr>
<tr>
<td></td>
<td>Barren</td>
<td>120</td>
<td>63,541</td>
<td>1,458</td>
<td>182</td>
<td>3,807</td>
<td>31</td>
<td>897</td>
</tr>
<tr>
<td></td>
<td>Forest</td>
<td>89,799</td>
<td>6,689</td>
<td>14,393,111</td>
<td>19,130</td>
<td>14,044</td>
<td>22,424</td>
<td>112,967</td>
</tr>
<tr>
<td></td>
<td>Grassland / Shrub</td>
<td>36,275</td>
<td>149</td>
<td>88,885</td>
<td>2,093,448</td>
<td>382</td>
<td>9,278</td>
<td>21,756</td>
</tr>
<tr>
<td></td>
<td>Open Water</td>
<td>12,487</td>
<td>3,127</td>
<td>21,627</td>
<td>3,287</td>
<td>3,032,070</td>
<td>742</td>
<td>25,059</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
<td>6,523</td>
<td>13</td>
<td>2,189</td>
<td>661</td>
<td>3,134</td>
<td>2,656,976</td>
<td>4,360</td>
</tr>
<tr>
<td></td>
<td>Wetlands</td>
<td>71,394</td>
<td>557</td>
<td>167,702</td>
<td>23,349</td>
<td>17,577</td>
<td>6,966</td>
<td>6,453,303</td>
</tr>
<tr>
<td>2001 Totals</td>
<td>24,337,402</td>
<td>76,098</td>
<td>14,772,610</td>
<td>2,172,424</td>
<td>3,157,374</td>
<td>2,739,779</td>
<td>6,728,806</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ag</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost</td>
<td>372,211</td>
<td>16,880</td>
</tr>
<tr>
<td>Gained</td>
<td>216,598</td>
<td>82,803</td>
</tr>
<tr>
<td>Total</td>
<td>-155,613</td>
<td>65,923</td>
</tr>
</tbody>
</table>
Outputs

• Ecosystem services
  – Carbon sequestration
  – Water quality (phosphorus exports in the Minnesota River Basin)

• Biodiversity
  – Grassland bird habitat
  – Forest bird habitat
  – Overall biodiversity (all natural habitat)

• Returns to landowners
  – Value of agricultural production
  – Value of timber production
  – Value of urban/suburban development
Change from 1992 to 2001 by scenario: carbon sequestration

Baseline  No Ag  No Urban  New Ag  New Forest  Conservation

Mg C

-80.0  -70.0  -60.0  -50.0  -40.0  -30.0  -20.0  -10.0  0.0  10.0  20.0
Change in phosphorus exports to mouth of Minnesota River

Baseline  No Ag  No Urban  New Ag  New Forest  Conservation

Mg P/yr

0  100  200  300

-100  -200  -300  -400  -500
Percentage change in habitat quality for grassland breeding birds

-4.0%  -3.0%  -2.0%  -1.0%  0.0%  1.0%  2.0%  3.0%

Baseline  No Ag  No Urban  New Ag  New Forest  Conservation
Percentage change in habitat quality for forest breeding birds

-15.0%
-10.0%
-5.0%
0.0%
5.0%
10.0%
Change from 1992 to 2001 by scenario: market returns to agriculture, forestry, urban

Agriculture

Baseline | No Ag | No Urban | New Ag | New Forest | Conservation

Baseline | $0 | $0 | $0 | $0 | $0
No Ag | $1,000 | $1,000 | $1,000 | $1,000 | $1,000
No Urban | $2,000 | $2,000 | $2,000 | $2,000 | $2,000
New Ag | $3,000 | $3,000 | $3,000 | $3,000 | $3,000
New Forest | $4,000 | $4,000 | $4,000 | $4,000 | $4,000
Conservation | $0 | $0 | $0 | $0 | $0

Forestry

Baseline | No Ag | No Urban | New Ag | New Forest | Conservation

Baseline | $0 | $0 | $0 | $0 | $0
No Ag | $0 | $0 | $0 | $0 | $0
No Urban | $0 | $0 | $0 | $0 | $0
New Ag | $0 | $0 | $0 | $0 | $0
New Forest | $0 | $0 | $0 | $0 | $0
Conservation | $0 | $0 | $0 | $0 | $0

Urban

Baseline | No Ag | No Urban | New Ag | New Forest | Conservation

Baseline | $4,000 | $4,000 | $4,000 | $4,000 | $4,000
No Ag | $3,000 | $3,000 | $3,000 | $3,000 | $3,000
No Urban | $2,000 | $2,000 | $2,000 | $2,000 | $2,000
New Ag | $1,000 | $1,000 | $1,000 | $1,000 | $1,000
New Forest | $0 | $0 | $0 | $0 | $0
Conservation | $0 | $0 | $0 | $0 | $0

Million 1992 US $
## Annual value from land use change scenarios 1992-2001

<table>
<thead>
<tr>
<th>Change in total value: carbon, water quality, ag &amp; forest production, urban using actual prices (M1992 $)</th>
<th>Baseline</th>
<th>No ag expansion</th>
<th>No urban expansion</th>
<th>Ag expansion</th>
<th>Forest expansion</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3,328</td>
<td>$3,407</td>
<td>$3,040</td>
<td>$2,742</td>
<td>$3,300</td>
<td>$3,380</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change in returns to landowners: ag &amp; forest production, urban using actual prices (M1992 $)</th>
<th>Baseline</th>
<th>No ag expansion</th>
<th>No urban expansion</th>
<th>Ag expansion</th>
<th>Forest expansion</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3,320</td>
<td>$3,343</td>
<td>$3,027</td>
<td>$3,418</td>
<td>$3,292</td>
<td>$3,221</td>
<td></td>
</tr>
</tbody>
</table>
Summary

- The failure to incorporate the value of ecosystem services in land use planning can result in poor outcomes
  - Low level of ecosystem services
  - Low value of total goods and services from landscape
- Agricultural land use change had a bigger effect on ecosystem service value and biodiversity than urbanization
  - Result is largely due to the fact that there is far more agricultural land than urban land
  - Urban land: generates negative externalities but the direct value of urban land use is high
  - Agriculture: generates negative externalities but with lower direct land use value
Summary

- Spatially explicit analysis of multiple services
- Joint provision of services: one landscape, many consequences
- Tools to address three related tasks of
  - Provision
  - Value
  - Policy
Thank you