Ecosystem Services and Natural Resource Restoration Projects

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Overview

- Context: Natural Resource Damage Assessment (NRDA)/Restoration
- Potential uses of ecosystem service models and values for natural resource restoration projects
- Examples in various contexts and spatial scales: wetlands in Delaware and California
Uses of Ecosystem Service Values

- Land use planning (e.g., targeting lands to purchase and/or manage for conservation).
- Demonstrate value to humans of natural resources at risk from catastrophic events (e.g., climate change).
- Describing benefits of land and resource conservation and management programs.
- Inform development of ecosystem markets.
- Inform targeting and prioritization of natural resource restoration projects.
NRDA

• The goal of NRDA is to compensate the public for losses in trust resources and resource services resulting from injury as a result of a discharge of oil or release of a hazardous substance.

• Compensation is measured as damages, calculated in projects or dollars.

• Compensation must restore, replace, or acquire the equivalent of lost resources or resource services.
“Resource Services” versus Ecosystem Services

Resource services: The physical and biological functions of the resource including the human uses of those functions.

Ecological:
- Nutrient cycling
- Provision of habitat
- Predator-prey interactions
- Organism viability
- Soil Formation

Millennium Ecosystem Assessment Categories of Ecosystem Services:
1. Provisioning Services
2. Regulating Services
3. Cultural Services
4. Supporting Services

Human Use:
- Recreation
- Drinking water
- Existence value
“Damages” versus Values

**Natural Resource Damages:** The amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources.

**Economic Values of Ecosystem Services:** Measure of the contribution of a good or service provided by an ecosystem to human well-being (inclusive of use and non-use values).
Ecosystem Services Valuation Approach

- Evaluate services as relevant to the policy question.
- Rather than looking at services on an individual basis, emphasize a complete accounting of services affected:
  1. **Describe**
  2. **Quantify**
  3. **Monetize**
- Make explicit the linkages between ecosystem function and value to human populations.
- Increased emphasis on valuing the services, but do not force monetization where available data and methods preclude reliable estimates.
Ecosystem Service Values and NRDA

- Estimate resource service losses associated with natural resource injuries.
- Demonstrate service benefits of restoration projects.
- Inform restoration planning (i.e., spatial planning for restoration projects).
# Models and Tools for Valuation

<table>
<thead>
<tr>
<th>User Interface</th>
<th>Model Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS model</td>
<td>InVEST</td>
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<tr>
<td></td>
<td>MIMES</td>
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<td></td>
<td>AIRES</td>
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<td>SOLVES</td>
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<td></td>
<td>ATEAM</td>
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<tr>
<td>Set of Structured Questions and/or Workbook</td>
<td>NVI</td>
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<td>ESV</td>
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<td>ESR</td>
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Models v. Site-Specific Service Analyses

- Ecosystem service models (e.g., InVEST, AIRES) are intended to be used at the landscape level and are therefore most appropriate to support restoration planning.
  - Broadscale GIS focus facilitates comparison of relative values over space
  - Trustees must select most cost-effective of equally preferable restoration alternatives.

- A site-specific service-by-service evaluation may be more appropriate to demonstrate the benefits of a given restoration project.
  - Availability of site-specific monitoring data following restoration activities
Key Points: Ecosystem Service Models

Data Requirements:
• Models are subject to same data requirements/data gaps (e.g., the effect of introduced contaminants on species populations, vegetation communities, or aesthetic quality).
• Ecosystem service models are a framework and rely on a significant number of inputs.

Valuation Components:
• No pre-packaged values are provided in the existing models and this is not a focus of the modeling efforts.
• Primary research may be required to monetize changes in certain services for which existing literature does not support a transfer (e.g., social and cultural values and biodiversity).
Example: Landscape Level Analyses

- InVEST application in Delaware (state-level evaluation)
- Ecosystem service losses associated with continued wetland decline throughout the state.
- Information can be used to target wetland conservation and restoration projects.

* InVEST developed by The Natural Capital Project: www.naturalcapitalproject.org/InVEST.html
Overview: InVEST Approach

• Integrated Valuation of Ecosystem Services and Tradeoffs
  • Series of open-source GIS models
  • Multiple services
  • Spatially explicit
  • Site-specific biological/physical data
  • Driven by policy-relevant scenarios
  • Biophysical and economic endpoints
## Services Evaluated: Delaware

<table>
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<tr>
<th>SERVICE</th>
<th>BIOPHYSICAL CHANGE</th>
<th>ECONOMIC VALUE</th>
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<tbody>
<tr>
<td>Carbon Storage:</td>
<td>Tons of C Stored</td>
<td>Social Cost of C</td>
</tr>
<tr>
<td>Water Purification:</td>
<td>N and P Loading, Sediment Loading</td>
<td>Avoided Treatment Costs</td>
</tr>
<tr>
<td>Biodiversity:</td>
<td>Level of Habitat Threat</td>
<td></td>
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<tr>
<td>Flood Control:</td>
<td>Storm Peak, Coastal Storm Surge</td>
<td>Avoided Damages (Land and Property Values)</td>
</tr>
</tbody>
</table>
Strengths and Limitations

- Biophysical models described water yield and nutrient and sediment transport across the landscape (for water quality analysis).

- Few models incorporate value component. We valued the biophysical endpoints outside of the model.

- Models are generalized in order to streamline consideration of multiple services across a broad area. To focus on a single site or single service, it may increase the precision of the value estimates to apply site- or service-specific models.
Example: Restoration Project Evaluation

- Quantified ecosystem service benefits of recent coastal wetland restoration project in Huntington Beach, California.

- Focus on evaluating ecosystem service benefits to augment recreational benefits analysis being developed.

- Planned to rely on InVEST but found models for relevant services were limited.

- Site- and service-specific analysis – site was unique as it was in an urban setting.
Services Evaluated: California

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<tr>
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<td>Tons of C Stored (41.3 tons per year)</td>
<td>Social Cost of C ($130,000 – present value, low end estimate)</td>
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<td>Aesthetic Improvements:</td>
<td>Acres of Wetland Present (108 acres)</td>
<td>Property Value Changes ($36 million)</td>
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<td>Habitat and Biodiversity Provisioning:</td>
<td>Improved Habitat Connectivity</td>
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- **Tons of C Stored:** (41.3 tons per year)
- **Acres of Wetland Present:** (108 acres)
- **Improved Habitat Connectivity**

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**Service:**
- **Biophysical Change:**
  - Tons of C Stored:
  - Acres of Wetland Present:
- **Economic Value:**
  - Social Cost of C ($130,000 – present value, low end estimate)
  - Property Value Changes ($36 million)
Strengths and Limitations

• Better accounting for site-specific factors that drive the provision of individual services.

• Much site-specific monitoring data…

• However, monitoring data were not gathered with a focus on meaningful measures for valuation (e.g., soil organic carbon).
Two Key Recommendations

1. Where resources allow, both the landscape-level modeling and site-specific analyses represent an improvement over schedule-based transfers of ecosystem service values (i.e., rapid assessments). This is due the importance of considering site-specific factors that drive the values of individual services.

   • Coastal wetlands example…
## Site-Specific Factors

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<tr>
<th>ECOSYSTEM SERVICE CATEGORIES</th>
<th>METHOD BY WHICH MARSH PROVIDES SERVICE VALUE</th>
<th>FACTORS INFLUENCING WHETHER A GIVEN MARSH SITE PROVIDES THE SERVICE</th>
</tr>
</thead>
</table>
| Climate stability           | Carbon is sequestered by and stored in soils and above and belowground biomass. This removes carbon from the atmosphere where it would otherwise contribute to climate change-associated damages. | • Type and density of vegetation  
• Soil accretion rates  
• Historical land use at the site affects soil organic carbon levels in deeper soils |
| Water quality improvements  | The marsh filters nutrients, such as nitrogen and phosphorus, and sediment, reducing the amount that reach waterways. This in turn reduces treatment costs or improves conditions for recreation. | • Proximity to nutrient and sediment loading land uses, such as agriculture or development  
• Capacity of the vegetation to filter sediment and nutrients  
• Connection of the marsh to a drinking water source  
• Direct uses of the marsh or connected water resources for recreation |
| Flood mitigation            | Coastal marshes buffer flooding by storing water and slowing flow across the landscape following a storm event. The value of this service is the decreased flood potential of productive land use. | • Capacity of the wetland soils to absorb water  
• Capacity of the wetlands to hold standing water  
• Capacity of the vegetation to slow water flows  
• Proximity to productive land use that is vulnerable to flood damage, such as development, agriculture, or transportation infrastructure |
## Site Specific Factors

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| Coastal protection          | Coastal marshes reduce storm damage by storing and slowing water during storms. | • Capacity of the wetland soils to absorb water  
• Capacity of the wetlands to hold standing water  
• Geographic situation between the coast and productive land use that is vulnerable to flood damage, such as development, agriculture, or transportation infrastructure |
| Habitat and biodiversity provisioning | Healthy coastal marshes are among the most diverse ecosystems, supporting a wide variety of plant species, birds, fish, and invertebrate species. | • Quality of wetland  
• Size of wetland  
• Proximity to developed land uses  
• Proximity to other viable marsh habitat |
| Recreation (fishing, hunting, wildlife-viewing, boating, swimming) | Marshes may directly provide opportunities for recreation by providing a site for fishing, hunting, boating, or wildlife viewing. They may also more indirectly improve wildlife-related recreation experiences at nearby sites by improving species richness and abundance (e.g., waterfowl for hunting or shorebirds for wildlife viewing). | • Extent of open water  
• Accessibility of the site for human populations  
• Presence of restrictions on recreational activities  
• Connectivity to other habitats that support recreational activities  
• Aesthetic quality of the site |
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</table>
| Commercial fishing and shellfishing              | Healthy marsh ecosystems may increase populations of commercially harvested fish and shellfish species in the region. | • Extent of open water  
• Accessibility of the site for human populations  
• Presence of restrictions on commercial harvest  
• Connectivity to other habitats that support commercial harvest |
| Property value benefits                           | The economics literature finds that humans are willing to pay a premium for residential properties near wetlands. Some properties may also benefit from improved views to the extent that native wetland habitats with a range of native species are preferred. In addition, humans may prefer the mix of flora and fauna supported by coastal marsh ecosystems than denuded land or single plant species landscapes. | • Relevant to restored marsh sites, the land use being replaced by the marsh  
• Size of wetland  
• Proximity to residential development  
• Accessibility to human populations in terms of viewscape or for wildlife-viewing |
| Cultural benefits                                | Particularly in areas that were historically rich with coastal marsh, human populations may value the presence of these ecosystems for their traditional value. | • Historical presence and use of regional marsh ecosystems  
• Presence of a culture that historically or presently relies on the site for subsistence, spiritual ritual, or tradition. |
Two Key Recommendations

1. Where resources allow, both the landscape-level modeling and site-specific analyses represent an improvement over schedule-based transfers of ecosystem service values (i.e., rapid assessments). This is due the importance of considering site-specific factors that drive the values of individual services.

   • Coastal wetlands example…

2. Ecologists and economists should collaborate early in the restoration planning process to identify monitoring data that would best inform measurement of economic values. E.g.,

   • Monitoring and data recommendations…
### Monitoring Efforts Focus for Valuation

<table>
<thead>
<tr>
<th>Service to Value</th>
<th>Meaningful Environmental Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Sequestration</td>
<td>• Soil accretion rates</td>
</tr>
<tr>
<td></td>
<td>• Carbon pools (e.g., tons of carbon per hectare in soils and biomass)</td>
</tr>
<tr>
<td>Water Purification</td>
<td>• Nutrient/sediment/contaminant loading and levels.</td>
</tr>
<tr>
<td>Flood Protection</td>
<td>• Flood heights and area</td>
</tr>
<tr>
<td></td>
<td>• Wetland depths</td>
</tr>
<tr>
<td>Recreation</td>
<td>• Numbers of recreators (fishing, birding, etc.)</td>
</tr>
<tr>
<td>Habitat Provisioning</td>
<td>• Species richness</td>
</tr>
<tr>
<td></td>
<td>• Species abundance</td>
</tr>
<tr>
<td></td>
<td>• Acres of habitat for sensitive species</td>
</tr>
</tbody>
</table>
ES and Natural Resource Restoration

Thank you

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