Applications of Ecosystem Services to Environmental Decision-Making: Understanding the Net Change

Joe Nicolette | Mark Rockel
Atlanta, GA | Philadelphia, FL
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Quantifying Services and Values

• Economic Methods to Determine the Present Discounted Value of Changes in Ecosystem Services Over Time
  – Ecological Services (Habitat Equivalency Analysis - HEA)
  – Direct Human Uses Such As Recreational Services (Economics Models: e.g., benefits transfer)
  – Indirect Use/Passive Use (e.g., contingent valuation; alternatively drops out of the equation)
Selecting Metrics to Represent Services

• Too many services provided to practically measure all of them
  – Typically select one or more metrics to use as a surrogate to represent services

• Ecological Services
  – Example metrics:
    • Fish Density (fish/hectare, fish/km, etc.)
    • Benthic Density (#/m2)
    • Vegetation Density (shoots/m2)
    • Others

• Direct human use services
  – Example metrics:
    • Visitor Days by Activity Type
      – Bicycling
      – Hiking
      – Bird Watching
      – Others
    • Note: Visitor Days Can be Converted to Dollars ($)

• Can select specific metrics or combination
  • Multiple curves
HEA Metric

- The typical metric is a measure of ecological services per acre per year or SAYs (service acre years)
- A discounting factor is applied to standardize the measure of services using a common base year DSAYs (discounted service acre years)
- HEA SAYs (debit and credit) represent time accumulated resource service flows
- As an example, a 10 acre wetland, provides, over a one year period, 10 SAYs of habitat services.
HEA Model Input Parameters: **Debit**

- Acreage of Habitat Exposed;
- Percentage of Habitat Services Lost (e.g., invertebrate abundance reduced by 25%);
- # of Years Needed for Injured Habitat to Fully Recover Naturally
- What is Shape of the Recovery Curve; and
- Real Discount Rate.
Conceptual Recovery Curves: Pulse Event
Individual Study Weighting

Water Quality

Baseline

Cumulative Percent (%) Recovery

Years

Note: Initial point of lost services will vary
Conceptual Recovery Curves: Pulse Event

Individual Study Weighting

Cumulative Percent (% Recovery)

Years

Water Quality
Macroinvertebrates

Baseline
Conceptual Recovery Curves: Pulse Event

Individual Study Weighting

Cumulative Percent (%) Recovery

Years

Water Quality  Macroinvertebrates  Fish

Baseline
Conceptual Recovery Curves: Pulse Event
Individual Study Weighting

Cumulative Percent (%) Recovery

Years

Water Quality  Macroinvertebrates  Corbicula  Fish

Baseline

ENVIRON
Conceptual Recovery Curve: Pulse Event
Weighted Based On Relative Importance of Each Metric

Cumulative Percent (%) Recovery

Years

Area A
Baseline
HEA Model Input Parameters:

“The Credit”

• Area of Influence (Enhanced/Created Area)
• Relative Productivity of Created vs. Natural Habitat;
• # of Years Needed for Created Habitat to Reach Maturity and What is Maturity Curve;
• Lifespan of Created Habitat; and
• Real Discount Rate.
Providing Services: The “Credit”

e.g., Habitat Enhancement

Area B is calculated in units of SAY’s

Baseline Services

Start of Project

Full Maturity

% of Services

Years

Providing Services: The “Credit”

e.g., Habitat Enhancement

Area B is calculated in units of SAY’s

Baseline Services

Start of Project

Full Maturity

% of Services

Years
Human Use Services: Example “Credit”

e.g., Creation of Bike Trail, Hiking Trail, Park

Area B is calculated in units of user days generated

Baseline Services
Quantifying Net Ecosystem Services: Comparing Impacts and Benefits Over Time

*Net Ecosystem Service Analysis (NESA)*

Impacts and benefits are based on changes from the baseline (pristine?).

**Area A - Services Lost (Loss)**

**Area B - Services Provided (Benefit)**

Environmental Economics-based Approaches
Use NESA to Develop Solutions

Strategies Designed to Balance the Risks, Benefits and Tradeoffs Associated with Competing Alternatives
Ecosystem Service Applications

Permitting
- Environmental Impact Analysis (EIA, EA, EIS)
- NPDES/TMDLs
- International Lending
- Tax Implications
- Liability Estimation: Insurers

Mitigation and Restoration
- Air Quality
- Payments for Ecosystem Services

Power Utilities (316a&b)
- Endangered Species Act

Endangered Species Act
- Damage Assessment

Environmental Sustainability
- Biodiversity Offsets

Surplus Property Valuation
- Due Diligence

Land Development and Management
- Mining Projects

Site Remediation

Mining Projects
- Environmental Impact Analysis (EIA, EA, EIS)
- NPDES/TMDLs
- International Lending
- Tax Implications
- Liability Estimation: Insurers

Endangered Species Act
- Damage Assessment

Environmental Sustainability
- Biodiversity Offsets

Surplus Property Valuation
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Land Development and Management
- Mining Projects

Site Remediation
## Alternative Comparisons

Example: NESA evaluates and compares how each management alternative (e.g., remedial alternative) affects:

<table>
<thead>
<tr>
<th>Scenario #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
</tr>
<tr>
<td>Management Actions (e.g., restoration projects, remedial alternatives, land use designs)</td>
</tr>
<tr>
<td>Alternative 1</td>
</tr>
<tr>
<td>Alternative 2</td>
</tr>
<tr>
<td>Alternative 3</td>
</tr>
<tr>
<td>Alternative 4</td>
</tr>
</tbody>
</table>

- Create more natural resource harm than that predicted by the risk assessment that drove the remedial action or
- Provide a marginal benefit compared to the effort expended.
Evolution of NESA in Remediation

Discussion, Approaches, and Presentations
Evolution of NESA in Remediation
OPERATIONAL SCIENCE ADVISORY TEAM-2 (OSAT-2)
SUMMARY REPORT FOR FATE AND EFFECTS OF REMNANT OIL
REMAINING IN THE BEACH ENVIRONMENT

Annex M: NET ENVIRONMENTAL BENEFITS ANALYSIS

INTRODUCTION AND BACKGROUND

Net environmental benefits are the gains in services (the sum total of the resources and processes that are inherently supplied by natural ecosystems) or attained by remedial actions, minus the environmental injuries caused by those actions. Net environmental benefit analysis (NEBA) is a methodology for comparing and ranking the pros and cons of different management alternatives. NEBA can be thought of as the evaluation of tradeoffs associated with cleanup or remediation to determine if the remedial action is warranted and sufficient. NEBAs can be conducted for a variety of stressors and management options, including chemical contaminant, hydropower, and global climate change mitigation proposals.

Efroymson et al. (2003) formalized the NEBA approach into a structured framework and noted that NEBA was an extension or elaboration of ecological risk assessment. They identified the key difference between the two processes as the consideration of environmental benefits, which traditional risk assessment does not incorporate. Efroymson et al. summarized the major advantages of NEBA in supporting management decisions:
Value of the NESA/NEBA Approach

- Provides information for management decisions using technical, scientific, and credible tools
  - Uses quantifiable metrics providing a basis for decisions
- Shows benefits to the public and demonstrates environmental sustainability
- Can result in better environmental management and greater environmental improvement at lower costs
- Methodologies are consistent with policy and direction of Agency Guidance and Directives
Case Studies
Case Study: Minnesota, Land Transfer/Donation

- Site (43 acres) Adjacent to Mississippi R.
- Marginal Contamination, Limited Risks
- Client wanted to donate to City, but wanted to capture full value
- Fair market value was $214,000
- Ecological value minimal
- Human use recreational value ≈ 30 Million dollars
- Donated to City
  - Expedited site closure
  - Received covenant-not-to-sue for NRD
  - Great public goodwill
Plans Announced for Riverfront Park:

City to Complete Bike Trail, Develop Park with Group's Gift of Land

From April 20, 2000 5:46 PM EDT HASTINGS, MN. PR Newswire

“... The appraised market value of the land is $215,000; its potential recreation value to the public is estimated at $30 million. The city's plans for the park include construction in 2001 of a community bandshell and an environmental interpretive center at the park's south end. Native plantings, nature boardwalks, a picnic shelter and a sculpture garden also are planned, with funding from a wide variety of sources. ... This gift of land, which will serve to complete Hastings 15 miles of bike trails, ...”
NESA Results: Remedial costs and risk profile changes for each remedial alternative evaluated.

Is There a Break-Point?
Where:
- Remediation action causes more harm than the risk driving the action
- proposed actions do not provide a sustainable solution.
or
- High cost for marginal change in risk
NESA Results:
Sustainability Framework

<table>
<thead>
<tr>
<th>Domain</th>
<th>Category</th>
<th>Sub-Category</th>
<th>MNA</th>
<th>Spot Removal</th>
<th>Surface Clearance</th>
<th>Clearance 2 Ft</th>
<th>Clearance 4 Ft</th>
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<tr>
<td>Environment</td>
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<tr>
<td></td>
<td></td>
<td>Net Habitat Impact (dSAYs)</td>
<td>0.0</td>
<td>(319.0)</td>
<td>(17,665.0)</td>
<td>(18,139.0)</td>
<td>(20,293.0)</td>
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<td></td>
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<td>Minimize Ecological Risk</td>
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<td>Remedial Cost (Million $)</td>
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<td>Human Use Asset Value (Million $)</td>
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<tr>
<td></td>
<td></td>
<td>Human Health Risk</td>
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<td></td>
<td></td>
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</tbody>
</table>

*ENVIRO*
Results: Environmental Stewardship and Sustainability Comparison
(more blue = more sustainable based on metrics evaluated)
Wetlands Issues:
Mitigation Scaling and Banking

Quantifying ecological changes helps determine best mitigation

Service-to-service method can be used to avoid over-compensating for environmental impact

Joseph P. Nicolette, CHEM HILL, Atlanta, Georgia; and Mark Rockel and Mary Jo Kealy, CHEM HILL, Philadelphia, Pennsylvania

A new method has been developed that can help operators determine the appropriate mix of mitigation measures for potential environmental impacts.

Known as the service-to-service method, it involves using an environmental metric to measure changes in ecological services—physical, chemical, and biological functions—that one natural resource provides for another natural resource over time.

This allows changes in ecological services resulting from injury ("debt") and mitigation ("credit") to be measured and quantified.

Quantifying service losses and gains allows the level of mitigation to be scaled appropriately, and thus helps operators avoid over-compensating for possible impacts. In a recent case, it was employed successfully to reduce one pipe line company's proposed mitigation requirements by more than 60%.

Mitigation requirements.
Increasingly, operators are being asked to compensate the public for environmental impacts they are perceived to have caused, or may cause in the future. These impacts, or potential impacts, may be the result of historic activities, construction of a new pipeline system, expansion of an existing line, accidental release of a contaminant into the environment or other action. In many cases, the pipeline company may be seeking to obtain a permit from the agencies involved, such as the Federal Energy Regulatory Commission (FERC), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Army Corps of Engineers (USACE).

A common result of these situations is that the pipeline industry is faced with numerous requests by federal, state, and local regulatory agencies to provide mitigation for potential environmental impacts. For example, the USACE may request that a company provide X number of acres of a certain type of habitat for each one acre harmed (a mitigation ratio), or the USFWS may request restoration of a particular type of habitat.

The pipeline industry is more than willing to provide the necessary mitigation; however, their common concern is whether or not they are over-compensating the regulatory agencies. In today's competitive energy markets, the cost of this mitigation can affect project viability. In addition, pipeline companies cannot afford schedule delays for protracted negotiations with regulators. This brings to light the need for a standardized methodology for developing appropriate mitigation, based on sound scientific information.

Service-to-service. The approach proposed here is known as the service-to-service approach. It is supported by numerous federal agencies (DOE, 1997; NOAA, 1997; EPA, 1999) and in Federal Court Rulings (USA vs. M. Flowers, 1997) as a valid approach for determining compensation for habitat impacts. The service-to-service approach is presented in the Oil Pollution Act 1990 final NEPA rule.

The service-to-service approach has also been used in multiple states across the U.S., including California, Texas, New Jersey, South Carolina, Virginia, Indiana, Louisiana, Florida, Oregon, Idaho, Alabama and others.

Natural resource services.
The Oil Pollution Act of 1990 states that services (or natural resource services) are...