Ecosystem Services in Land Management Decision Making: Development and Application of EcoAIM™ at Aberdeen Proving Ground

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Acknowledgments

• Partners
  – Dr. Jessica Turnley, Galisteo Consulting—Social Anthropologist
  – Dr. James Boyd, RFF—Natural Resource Economist

• APG Personnel
  – John Wrobel—Acting Chief, DPW Natural Resources Branch
  – Dr. Deidre DeRoia—Biologist, DPW Environmental Division
  – Bryant Debruyne—Senior GIS Specialist, Michael Baker Jr. Inc.

• ESTCP
  – Dr. John Hall—Program Manager, Resource Conservation and Climate Change
What We Will Cover Today

- What EcoAIM™ is
- A little background on APG and the project
- Geospatial models applied at APG
  - Visual/landscape aesthetics
  - Nitrogen sequestration
  - Recreation
  - Habitat provisioning for biodiversity
- Illustrative scenario and results
Project Background

- Dept. of Defense owns/manages >30 million acres
- Spends $4 billion/year on management to meet regulatory and mission requirements
- Missions affect ecosystem services (ES)
- Quality of ecosystem services have effect on missions
- Objective was to adequately account for ES tradeoffs to ensure sustainability of DoD mission at installations
Aberdeen Proving Ground

- Located in Maryland, on Chesapeake Bay
- 72,000 acres
- Active proving ground for testing weapons and technology
- BRAC-gaining installation
- Hosts 66 tenants (e.g., Chemical and Biological Center, Army R&D, etc)
What EcoAIM™ Is

A decision support framework and geospatial tool for managing ecological assets

- Main objective is trade-off analysis via scenario building
- Scalable process and tool
  - Spatial—project, parcel, watershed, geopolitical/management unit
  - Data needs—should not require data collection
  - Modeling sophistication—determined by need
- Focus on non-monetary quantification
  - Beneficiary preferences weighting
  - Relative ranking and proportional change
The EcoAIM™ Decision Support Framework

Problem formulation: Define decision space
- Objectives and priorities
- Ecosystem services of primary concern
- Define ecological production functions
- Identify endpoints stakeholders value

Develop and refine modeling parameters

Stakeholder Engagement

EcoAIM™ Spatial Analysis Tool
Stakeholder Engagement Objectives

- Clarify installation’s organizational structure
- Understand the natural resource management decision making process
- Describe how information flows within the organization
- Identify stakeholders’ and beneficiaries’ roles in decision making
Example Outcome: Mindmap of APG and Ecosystem Services

Mission:
- Provide World Class Data to Attract a Robust Set of Customers

Vision:
- Satisfy Regulatory Requirements
- Expand and Sustain a Brain Trust
- Be a Good Corporate Citizen
- Pollution Attenuation (Wetlands)
- Recreation
- Biodiversity

Ecosystem Services:
- Visual Aesthetics

* stakeholder-derived mission
Models Selected to Reflect the ES of Greatest Importance to APG

• Aesthetics
  – Vista
  – Landscape
• Habitat provisioning for biodiversity
• Recreation
• Nutrient sequestration
Scenario Building and Analysis

- User can create polygons and see changes in ES scores by comparing to each other and to baseline
- Drill down to parcels to determine drivers
- Understand trade-offs between different ES
Landuse Change Scenario
Calculating Relative Ranking of Ecosystem Services

1. Landform contrast
2. Wetland-edge complexity
3. Associated water-body size
4. Associated water-body diversity
5. Surrounding land-use contrast
6. Surrounding land-use diversity
7. Wetland size
8. Vegetative/water interspersion

3. Overall wetland aesthetics scores

- 80
- 60
- 55
- 40
- 56
- 10
- 35
- 23
- 12
- 21

4. Overall wetland aesthetics rank

- 10
- 9
- 8
- 7
- 6
- 5
- 4
- 3
- 2
- 1

Example: Wetland size

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Vista Aesthetics
Vista Aesthetics Baseline

Visibility Parameters

Observer Parameters
Observer offset: 0 Z units
Minimum view radius: 100 map units
Maximum view radius: 100000 map units
Horizontal FOV: 60 degrees

Calculated Parameters
Line azimuth: 319.87 degrees
Start angle: 289.87 degrees
Swept angle: 349.87 degrees

Landscape Metrics

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<td>11</td>
<td>Open Water</td>
<td>3</td>
</tr>
<tr>
<td>211</td>
<td>Open Space</td>
<td>2</td>
</tr>
<tr>
<td>213</td>
<td>Golf Course</td>
<td>2</td>
</tr>
<tr>
<td>215</td>
<td>Training Area</td>
<td>-1</td>
</tr>
<tr>
<td>241</td>
<td>Vehicle Driveway Area</td>
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</tr>
<tr>
<td>242</td>
<td>Vehicle Parking Lot</td>
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</tr>
<tr>
<td>243</td>
<td>Road</td>
<td>-1</td>
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</tbody>
</table>

Patch richness: 14
Viewshed area: 1,926,732.258
Shannon’s diversity index (SDi): 1.000
Landscape Aesthetics
Forest Landscape Aesthetics

- Landform Contrast
- Edge Complexity
- Surrounding Landuse Contrast
- Surrounding Landuse Diversity
- Forest Size
- Vegetation Interspersion
- Forest Density
- Forest Age
Nutrient Sequestration
Calculate the nutrient and NPS contaminants loadings to the wetland

Pre-wetland NPS loading (lbs/yr) | Loading reduction (lbs/yr) | Post-wetland NPS loading (lbs/yr)
--- | --- | ---
TDS | 440679.14 | U | U
TN | 1734.86 | 173.49 | 1561.37
TKN | 1404.8 | U | U
DP | 56.39 | U | U
TP | 206.52 | 51.63 | 154.89
CADMIUM | 1.57 | .79 | .79

Riparian Analysis Toolbox
Determine the effectiveness (percent) of the wetland regarding nutrient and NPS contaminant reduction, based on buffer width, average slope, vegetation strip width, etc.

Reduction effectiveness

TN = 10%
TP = 25%
Total Nitrogen Loadings into Each Wetland
Total Nitrogen Outflow from Each Wetland
## Final Results: ES Average Scores and Percent Change

<table>
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<tr>
<th>ES</th>
<th>Baseline Case</th>
<th>Scenario 1</th>
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<tr>
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<td>Landscape Aesthetics</td>
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<td>Recreation</td>
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<td>Nutrient Sequestration</td>
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<tr>
<td>Vista Aesthetics</td>
<td>Patch Richness: 14</td>
<td>Patch Richness: 3</td>
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<tr>
<td></td>
<td>Area (sq ft): &gt;1.9 million</td>
<td>Area (sq ft): ~882,000</td>
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<tr>
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<td>SDI: 1.0</td>
<td>SDI: 0.96</td>
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</table>

![Bar chart showing percent change for different ES categories]
Main Take Home Points

• Successful application of any ES quantification tool requires consideration of management context and decision space
  – Prioritizing modeling efforts
  – Interpreting and communicating results
• Flexible decision support framework allows for appropriate scaling of modeling and management application
• Flexible modeling approach allows for relative or absolute quantification of ES
THANK YOU!
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