Ecosystem services tradeoffs on behalf of future generations

Georgia Mavrommati, Shannon Rogers,
Mark Borsuk and Richard Howarth

Ecological Economist, Ph.D.
Postdoctoral Research Associate
Environmental Studies Program
Dartmouth College
Email: Georgia.Mavrommati@dartmouth.edu
Outline of Today’s Talk

1. Main Research Questions and Methodology
2. Application to the Upper Merrimack River Watershed
3. Results
4. Discussion
Main Research Questions:

1. How do we value ecosystem services in a way that respects the needs of future generations?

2. Do the anticipated values of ecosystem services differ under alternative future scenarios?

Literature gap:
Temporal dimensions of ecosystem service values
Challenges with Conventional Valuation Approaches

1. Ecosystem services typically embody characteristics that go beyond self-interested value

2. Future human preferences are unknown

3. Ecosystem services are complex with multiple interactions
Combines the advantages of multicriteria decision analysis with local knowledge-building through deliberation.

- Allows for environmental attributes that have different measurement units and/or cannot be quantified in monetary units.
- Allows for the construction of social values through discourse-based interaction among citizens or stakeholders and scientists.

Key Literature: Garmendia and Gamboa, 2012; Karjalainen et al., 2013; Kelemen et al., 2013; Liu et al., 2011; Liu et al., 2010; Petts, 2001; Proctor and Drechsler, 2006
Deliberative Multi-Criteria Evaluation (DMCE)

- Provides a framework for communicating the science behind ecosystem services measures
- Engages the public in decision making in the form of a “citizens jury.”
  → Improves shared understanding and reduces likelihood of conflict

Key Literature: Garmendia and Gamboa, 2012; Karjalainen et al., 2013; Kelemen et al., 2013; Liu et al., 2011; Liu et al., 2010; Petts, 2001; Proctor and Drechsler, 2006; Rauschmayer and Wittmer, 2006; Straton et al., 2011
How do we bring consideration for the future into the process?

• By considering predicted levels of ecosystem services for 2100 as compared to the present.

• By asking participants to serve as “trustees” who represent the well-being of future generations under the given scenario.

• By presenting alternative “hypothetical futures” that include aspects such as land use, infrastructure, and economic growth.
The anticipated values of ecosystem services differ under alternative future scenarios, therefore:

→ We expect that the relative values that groups place on various ecosystem services will differ according to the future scenario presented to them.
Application to the Upper Merrimack River Watershed

Watershed includes:

- Pemigewasset, Contoocook, and Merrimack Rivers
- Squam Lake and Lake Winnipesaukee
- Concord and Manchester
- Population of 410,000
# Ecosystem Services Considered

<table>
<thead>
<tr>
<th>Domain</th>
<th>Ecosystem Service</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Farmland</td>
<td>acres per person</td>
</tr>
<tr>
<td></td>
<td>Forest Cover</td>
<td>% of total land area</td>
</tr>
<tr>
<td></td>
<td>Forest Type</td>
<td>% of forest</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td>Heat Stress</td>
<td>days</td>
</tr>
<tr>
<td></td>
<td>Winter Recreation</td>
<td>days</td>
</tr>
<tr>
<td></td>
<td>Spring/Summer Recreation</td>
<td>days</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>River Habitat</td>
<td>% river miles</td>
</tr>
<tr>
<td></td>
<td>Coastal Health</td>
<td>Kg tons N / Year</td>
</tr>
<tr>
<td></td>
<td>Water Provision</td>
<td>Million Person*Days</td>
</tr>
<tr>
<td></td>
<td>Flood Attenuation</td>
<td>K Person*Days</td>
</tr>
</tbody>
</table>
Each ecosystem service $i$ is represented by a particular ‘attribute’, or measurable variable, $y_i$.

The overall value of any ‘bundle’ of ecosystem services is then represented as a weighted sum of the values for single attributes:

$$ \nu(y) = \sum w_i \nu_i(y_i) $$

where $w_i$ are the attribute weights representing the relative importance of ecosystem services.

Weights can be determined from a series of preference choices over specified bundles of ecosystem services.
Alternative Future Scenarios

- Population increases from 410,000 to 1.1 million by 2100
- Primary job creation is in service industry
- Development is rapid and sprawling
- Shrinking role of state agencies

- Population decreases from 410,000 to 373,000 by 2100
- Development occurs as redevelopment or in-fill
- Investment in education and workforce development promotes new high tech and manufacturing industries
- Policies promote collective needs
Alternative Future Scenarios

2 workshops
5 groups total
5-6 participants per group

Backyard Amenities

Community Amenities & Local Food

2 workshops
6 groups total
5-6 participants per group
Hypothesis 1:

We expect that the relative values that groups place on ecosystem services will differ according to the future scenario presented to them.

![Land Domain Graph](image-url)
Results: Tradeoff weights for each scenario

Climate Domain

Weight

0.8
0.6
0.4
0.2
0

Hot Days
Snow Cover
Recreation Days

B
C
B
C
B
C
Results: Tradeoff weights for each scenario

Water Domain

Weight

Fish Habitat  Coastal Harm  Water Provision  Flooding
Results: Tradeoff weights for each scenario across domains

Across Domains

Weight

0.7
0.6
0.5
0.4
0.3
0.2
0.1

B
C
B
C
B
C

Water
Climate
Land
Why? Exploring possible explanations

Our Hypothesis is not supported by the data

1. Participants are not sufficiently aware of their role or the scenario under consideration.
2. Participants consideration of the acceptable magnitude of change, substitutes/avoidance measures outweigh any influence from the type of scenario

Methods: Combined qualitative and quantitative analysis
Hypothesis 1: Participants are not aware of their role

Participants do consider future generations interests
Themes of discussion based on content analysis:
• Climate refugees
• Safeguarding the Watershed for the future
• Uncertainty about the future conditions and wants
• Concerns for children and grandchildren
• Freedom of choice
• Retrospective analysis
Hypothesis 1: Participants are not sufficiently aware the scenario under consideration.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Group</th>
<th>Are participants aware of the scenario year?</th>
<th>Are participants aware of population changes?</th>
<th>Are participants aware of economic growth/job/transportation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>Group 1</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Group 2</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>Group 3</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Group 4</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>Group 5</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>Group 6</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Group 8</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>Group 9</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Group 10</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>
Hypothesis 2: Participants considerations of the acceptable magnitude of change, substitutes and/or avoidance measures outweigh any influence from the type of scenario.
Hypothesis 2: Participants' considerations of the acceptable magnitude of change, substitutes and/or avoidance measures outweigh any influence from the type of scenario.
Water

- River Habitat
- Coastal Health
- Water Shortage
- Flood Attenuation
Tradeoff weight vs normalized change for Water.

- River Habitat
- Water Shortage
- Coastal Health
- Flood Attenuation

High magnitude of change with avoidance measures.
Discussion

Methodological implications:
• Discoursed-based methods provide the framework to assess robust social values
• Discoursed–based methods cultivate social learning and may increase the willingness to support conservation policies

Policy Implications:
• “Acceptable” ecosystem services tradeoffs on behalf of future generations that are tolerable by the current generation
This work was funded primarily by the **National Science Foundation** through the New Hampshire Experimental Program to Stimulate Cooperative Research (EPSCoR).

Additional funding was obtained from Dartmouth College through the Presidential Junior Research Fellowship Program.
Thanks! Any questions?
• Participants were asked to arrange cards representing different “bundles” of ecosystem service levels along a meter stick.

• Order represents preference ordering and relative spacing represents the relative difference in preferences.

• This was done separately for each of the three ecosystem service domains (land, water, climate) and then across domains.

→ In the deliberative framework, preferences are not personal but are socially constructed.
Participant Demographics

Gender
- 51% Female
- 49% Male

Age Group
- 11 people aged 18 to 40
- 9 people aged 41 to 50
- 24 people aged 51 to 60
- 23 people over 60

Political Affiliation
- Conservative: 29%
- Liberal: 28%
- Moderate/Unknown: 43%

Income
- Prefer Not to Answer: 49%
- More than $100,000 per year: 11%
- $75,001 to $100,000 per year: 29%
- $50,001 to $75,000 per year: 33%
- $25,001 to $50,000 per year: 15%
- Less than $25,000 per year: 5%
Workshop Implementation

Step 1: Preparing the participants
Step 2: Individual Pre-Deliberation Surveys
Step 3: Group Deliberative Evaluations
Step 4: Individual Post-Deliberation Surveys
## Calculation of Weights for Climate Attributes

<table>
<thead>
<tr>
<th>Swing</th>
<th>Rating</th>
<th>100-Rating</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Days</td>
<td>0</td>
<td>100</td>
<td>0.45</td>
</tr>
<tr>
<td>Snow</td>
<td>5</td>
<td>95</td>
<td>0.43</td>
</tr>
<tr>
<td>Recreation</td>
<td>75</td>
<td>25</td>
<td>0.11</td>
</tr>
<tr>
<td>All Best</td>
<td>100</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Sum =</strong></td>
<td></td>
<td><strong>220</strong></td>
<td></td>
</tr>
</tbody>
</table>
Application

- Resulting multiattribute value function can be used to assess the anticipated relative desirability of other possible scenarios to the state’s future citizens.

\[ v(y) = \sum w_i v_i(y_i) \]
Hypothesis 1:

We expect that the relative values that participants place on various ecosystem services will converge after deliberation.

Results

<table>
<thead>
<tr>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
<th>Participant 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 3 1</td>
<td>1 2 3</td>
<td>2 1 3</td>
<td>1 2 3</td>
<td>2 3 1</td>
<td>1 2 3</td>
</tr>
<tr>
<td>3 1 2</td>
<td>2 3 1</td>
<td>3 1 2</td>
<td>2 3 1</td>
<td>3 1 2</td>
<td>2 3 1</td>
</tr>
<tr>
<td>3 2 1</td>
<td>1 2 3</td>
<td>3 2 1</td>
<td>2 3 1</td>
<td>3 4 1</td>
<td>2 3 1</td>
</tr>
<tr>
<td>2 4 1</td>
<td>1 3 4</td>
<td>4 2 1</td>
<td>3 4 1</td>
<td>1 3 4</td>
<td>2 3 1</td>
</tr>
</tbody>
</table>

SD = 0.89

<table>
<thead>
<tr>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
<th>Participant 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 3 2</td>
<td>1 3 2</td>
<td>1 2 3</td>
<td>1 2 3</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>2 1 3</td>
<td>2 1 3</td>
<td>2 1 3</td>
<td>1 2 3</td>
<td>2 3 1</td>
<td>1 2 3</td>
</tr>
<tr>
<td>2 1 3</td>
<td>1 2 3</td>
<td>3 1 2</td>
<td>3 1 2</td>
<td>1 2 3</td>
<td>3 1 2</td>
</tr>
<tr>
<td>3 1 2</td>
<td>1 2 3</td>
<td>3 1 2</td>
<td>3 1 2</td>
<td>1 2 3</td>
<td>3 1 2</td>
</tr>
</tbody>
</table>

SD = 0.64

Average across groups

SD = 0.84

SD = 0.64

SD = 0.51