Socioeconomic Evaluation of the Impact of Natural Resource Stressors on Human-Use Services in the Great Lakes Environment: A Lake Michigan Case Study

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Pathways to Success 2012
Integrating Human Dimensions into Fish and Wildlife Management
The Colcom Foundation

- Located in Pittsburgh, PA
- Focuses research efforts on the GLE
- $20 million in grant awards per year
- This project based on $115K grant
Definition of Carrying Capacity

• Seeking overarching definition that covers many disciplines
  – Environmental economics: amount of economic activity an area can support before ecological and human-use services deteriorate or disappear
  – Agricultural economics: constant units of output per hectare during non-disaster years
  – Recreational use: maximum number of visitors an area can support without degrading resources and/or the quality of the visitor experience
Definition of Carrying Capacity (cont.)

– Engineering: Maintaining desirable system response by controlling inputs and feedback
  • choose suitable system metric
  • sustainable system design: establish margin of tolerance for variability in the metric
  • control measures: interface between engineering design and policy

– Biology
  • Constant biomass per unit of surface area
  • Constant amount of renewable resources and number of organisms those resources can support

– Population density
  • Amount of people an area can support given economic, biological, and physical limitations
  • Can be enhanced by technology and trade

– Our definition: a systems metric is defined that, when viable per associated viability criteria, ensures that critical system constraints will be sustained.
Project Disciplines

- Two overlapping disciplines
  - Environmental economics: assessing public preferences of environmental stressors as function of awareness, understanding, attitudes, and opinions
  - Civil engineering: developing a systems model using economic results as inputs to prioritize model elements
Identification of Stressor Areas

• Literature survey for regional topics
  – Development of literature database
  – Over 100 entries

• Consulted with regional and local stakeholders
  – Green Grand Rapids
  – Grand Rapids Department of Parks & Recreation
  – Alliance for the Great Lakes
  – Council of Great Lakes Governors
  – Great Lakes Commission
  – National Wildlife Federation
Nine Stressor Areas Emerged

1. Pollution/contamination of natural resources  
   • PCBs causing FCAs
2. Risk of drinking water shortage  
   • Increase in water withdrawals will lower lake water levels
3. Loss of wetlands or other wildlife habitat  
   • Critical to maintain local ecosystems
4. Erosion of agricultural land  
   • Change in land use destroys wildlife habitat
5. Invasive species  
   • Non-indigenous species interact with the ecosystem in unpredictable ways
Nine Stressor Areas Emerged

6. Population overcrowding
   • Urban sprawl is consuming previously healthy environments’ habitats

7. Degraded recreational resources
   • Lower Fox river and Green bay - recreational fishing damages estimated between $106 to $148 million ($US1999)

8. Climate change
   • Lower water levels impact fish and wildlife habitat

9. Vanishing sand dunes from overmining
   • Dunes are home to diverse and unique wildlife and plant species
   • Dunes provide shelter for neighboring coastal marshes

* Note that all nine could affect fisheries and wildlife!
Focus Groups

• Critical (but often forgotten) first step in developing valuation survey and model
• Four focus groups over two days during summer in Grand Rapids
• Pretested with group of Michigan Tech faculty and students
• N=46 (11 to 12 people per group)
• Written survey instruments followed by oral discussions with two team members
Some Key Themes

• Education → Awareness → Concern → Value
• Care for future generations but lack of understanding about how stressors affect future
• Most concern linked directly or indirectly to water (use and contamination)
• Most concern linked to direct, active uses
• Lack of concern/action for problems that are not immediate, or for which they cannot see immediate impact
Disconnect for Climate Change

- Scientists, economists, and policy makers very interested
- Many local and regional studies mostly confirming human causes and impact
- Yet, the general public largely indifferent (regardless of education, political affiliation, or gender)
- Some even think it’s a hoax
Focus Group Handouts

A – Environmental issues versus other issues
B – Use of resources – recreation
C – Awareness of stressors and sources of info
D – Concern: priorities for management actions
E – Socioeconomic and demographic variables
Data analysis

• Summary statistics: means and standard errors
• Coding verbal responses as numerical variables
• Hypothesis testing: two-sample tests of means, chi-squared tests
• Covariates: political affiliation and education
Table 1. Question C1: Have you heard, seen, or read about any of the following issues in your area?

<table>
<thead>
<tr>
<th>Stressor category</th>
<th>NOBS</th>
<th>Frequency</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1(=Never)</td>
<td>2(=Maybe)</td>
<td>3(=Definitely)</td>
<td>Mean</td>
<td>Standard error</td>
<td></td>
</tr>
<tr>
<td>Pollution</td>
<td>45</td>
<td>9%</td>
<td>22%</td>
<td>69%</td>
<td>2.60</td>
<td>0.097</td>
<td></td>
</tr>
<tr>
<td>Invasive species</td>
<td>43</td>
<td>19%</td>
<td>19%</td>
<td>63%</td>
<td>2.44</td>
<td>0.121</td>
<td></td>
</tr>
<tr>
<td>Agricultural erosion</td>
<td>42</td>
<td>19%</td>
<td>29%</td>
<td>52%</td>
<td>2.33</td>
<td>0.121</td>
<td></td>
</tr>
<tr>
<td>Climate change</td>
<td>45</td>
<td>16%</td>
<td>36%</td>
<td>49%</td>
<td>2.33</td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td>Loss of wetlands</td>
<td>45</td>
<td>18%</td>
<td>44%</td>
<td>38%</td>
<td>2.20</td>
<td>0.108</td>
<td></td>
</tr>
<tr>
<td>Recreational degradation</td>
<td>44</td>
<td>39%</td>
<td>41%</td>
<td>20%</td>
<td>1.82</td>
<td>0.114</td>
<td></td>
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<tr>
<td>Vanishing sand dunes</td>
<td>45</td>
<td>53%</td>
<td>27%</td>
<td>20%</td>
<td>1.67</td>
<td>0.119</td>
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</tr>
<tr>
<td>Clean water depletion</td>
<td>46</td>
<td>57%</td>
<td>28%</td>
<td>15%</td>
<td>1.59</td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td>Population overcrowding</td>
<td>46</td>
<td>57%</td>
<td>33%</td>
<td>11%</td>
<td>1.54</td>
<td>0.102</td>
<td></td>
</tr>
</tbody>
</table>

a. Detail may not sum to 100% due to rounding.
Table 2. Question D1: How concerned are you about any of the following environmental issues?

<table>
<thead>
<tr>
<th>Stressor category</th>
<th>NOBS</th>
<th>Frequency</th>
<th></th>
<th></th>
<th></th>
<th>Mean</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 (=Not at all)</td>
<td>2 (=Slightly)</td>
<td>3 (=Moderately)</td>
<td>4 (=Very)</td>
<td>5 (=Extremely)</td>
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<tr>
<td>Pollution</td>
<td>44</td>
<td>2%</td>
<td>7%</td>
<td>15%</td>
<td>54%</td>
<td>22%</td>
<td>3.91</td>
</tr>
<tr>
<td>Agricultural erosion</td>
<td>40</td>
<td>4%</td>
<td>13%</td>
<td>30%</td>
<td>41%</td>
<td>11%</td>
<td>3.41</td>
</tr>
<tr>
<td>Invasive species</td>
<td>37</td>
<td>11%</td>
<td>16%</td>
<td>18%</td>
<td>37%</td>
<td>18%</td>
<td>3.34</td>
</tr>
<tr>
<td>Recreational degradation</td>
<td>43</td>
<td>4%</td>
<td>24%</td>
<td>24%</td>
<td>38%</td>
<td>9%</td>
<td>3.22</td>
</tr>
<tr>
<td>Loss of wetlands</td>
<td>43</td>
<td>7%</td>
<td>16%</td>
<td>40%</td>
<td>27%</td>
<td>11%</td>
<td>3.20</td>
</tr>
<tr>
<td>Climate change</td>
<td>42</td>
<td>11%</td>
<td>23%</td>
<td>25%</td>
<td>20%</td>
<td>20%</td>
<td>3.14</td>
</tr>
<tr>
<td>Clean water depletion</td>
<td>41</td>
<td>28%</td>
<td>20%</td>
<td>22%</td>
<td>22%</td>
<td>9%</td>
<td>2.63</td>
</tr>
<tr>
<td>Vanishing sand dunes</td>
<td>36</td>
<td>20%</td>
<td>31%</td>
<td>29%</td>
<td>16%</td>
<td>4%</td>
<td>2.53</td>
</tr>
<tr>
<td>Population overcrowding</td>
<td>44</td>
<td>41%</td>
<td>15%</td>
<td>33%</td>
<td>9%</td>
<td>2%</td>
<td>2.15</td>
</tr>
</tbody>
</table>

a. Detail may not sum to 100% due to rounding.
Table 3. Question D2: If money were available, actions could be taken to address these environmental issues. However, there will never be enough money to do everything. Please tell us your preferences on the following actions?

<table>
<thead>
<tr>
<th>Stressor category</th>
<th>NOBS</th>
<th>Frequency(^a)</th>
<th></th>
<th></th>
<th></th>
<th>Mean</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 (=Do less, spend less)</td>
<td>2 (=Do the same as usual)</td>
<td>3 (=Do more, spend more)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollution</td>
<td>44</td>
<td>2%</td>
<td>9%</td>
<td>89%</td>
<td></td>
<td>2.86</td>
<td>0.062</td>
</tr>
<tr>
<td>Agricultural erosion</td>
<td>40</td>
<td>10%</td>
<td>33%</td>
<td>58%</td>
<td></td>
<td>2.48</td>
<td>0.107</td>
</tr>
<tr>
<td>Recreational degradation</td>
<td>43</td>
<td>2%</td>
<td>47%</td>
<td>51%</td>
<td></td>
<td>2.47</td>
<td>0.084</td>
</tr>
<tr>
<td>Invasive species</td>
<td>37</td>
<td>3%</td>
<td>49%</td>
<td>49%</td>
<td></td>
<td>2.43</td>
<td>0.091</td>
</tr>
<tr>
<td>Loss of wetlands</td>
<td>43</td>
<td>5%</td>
<td>56%</td>
<td>40%</td>
<td></td>
<td>2.35</td>
<td>0.087</td>
</tr>
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<td>0.105</td>
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<td>0.102</td>
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<td></td>
<td>1.66</td>
<td>0.092</td>
</tr>
</tbody>
</table>

\(^a\) Detail may not sum to 100% due to rounding.
Development of system model

• Values of system parameters estimated from literature review and focus groups
  – Population demographics and growth rates
  – Resource consumption behavior
  – Growth in urban infrastructure

• Study of dynamic behavior
  – Economic input-output (greenhouse gases; energy/waste generation)
  – Environmental impact analysis
  – Benefit-cost analysis

• Grounded in agent-based modeling approaches

• Estimates long-term environmental and economic impacts of human activity
  – Industrial, technological, recreational
  – Prediction of the long-term behavior of carrying capacity
A System Dynamics Approach

- Public Preferences
- Expert Opinion
- Adoption Loop
- Knowledge Loop
- Public Policy
- Environmental Systems
Carrying Capacity

The population $P$ that can be supported by a natural resource $N$

Per-capita natural resource consumption:
- $N/P = c$

Sustainability:
- A state of dynamic equilibrium
- Maintain $c$ by controlling $N$ or $P$ or $c$
Challenges

Assessing priorities
Modeling resource constraints & relationships
Integrating individual relationships into a system model
Estimating value and impact on a natural resource
Demonstration and Application: Bear Lake Case Study

- Focus groups clearly indicate pollution/contamination primary concern
- Also concerned for active-use services (e.g., recreation) and future fresh water depletion
- Estuary of Lake Michigan with nutrient (phosphorus) issues → excess algal growth