Evaluating market and non-market costs of invasive fish

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Overview

- Characterizing the problem in a benefit / cost framework
- Existing studies: how do they fit into the framework?
  - Benefit estimation: Individuals
    - Willingness to Pay/Willingness to Accept
    - Revealed Preference methods
    - Hedonics: property value studies
    - Travel Cost
    - Averting Expenditure
    - Stated Preference methods
  - Benefit estimation: Producers
    - Producer Surplus
Marginal Control Costs

Zero Control: Maximum Population Size

Maximum Control: Eradication

Control of Invasive Species
Marginal Benefits

$\text{Marginal Benefit (MB)}$

Zero Control: Maximum Population Size

Maximum Control: Eradication

Control of Invasive Species
Total Benefits and Damages

- **Zero Control:** Maximum Population Size
- **Maximum Control:** Eradication

**Control of Invasive Species**

- **Total Benefits (Damages Avoided)**
- **Damages Incurred**

$MB$
Putting it together

Control of Invasive Species

Net Benefits

Total Damages

Maximum Control: Eradication

Control level

Zero Control: Maximum Population Size

Total Control Costs

MB

MCC

$
Corresponding Totals

Control of Invasive Species

Zero Control: Maximum Population Size
Max Net Benefits
Maximum Control: Eradication

Benefits
Control Costs

$
No Control

Zero Control:
Maximum Population Size

Maximum Control:
Eradication

Total Damages

Control of Invasive Species
Maximum Control

Total Benefits - Total Control Costs = Net Benefits

\[(A+B) - (B+C) = A-C\]

- **Zero Control:** Maximum Population Size
- **Maximum Control:** Eradication

**MB**
- Total Benefits (Damages Avoided)

**MCC**
- Total Control Costs

**A**
- Net Benefits

**B**
- Control of Invasive Species

**C**
- (A+B) - (B+C) = A-C
At the Optimum:

Maximizes Net Benefits
Minimizes Total Control Costs + Damages Incurred

Net Benefits
Total Control Costs
Damages incurred

Zero Control: Maximum Population Size
Control level
Maximum Control: Eradication

Control of Invasive Species
Too Much Control

Control of Invasive Species

Control level

Zero Control: Maximum Population Size

Maximum Control: Eradication

Total Control Costs

Excess Costs

Damages incurred

$
Too little control

Net Benefits

Zero Control: Max Pop Size

Total Control Costs

Excess Damage

Control level

Control of Invasive Species

Max Control: Eradication

Damages Incurred

$
Eradication Optimal

Control of Invasive Species

Net Benefits

Total Control Costs

Zero Control: Maximum Population Size

Maximum Control: Eradication

$
No Control Optimal

$\text{Total Damages}$

$\text{Zero Control: Max Pop Size}$

$\text{Maximum Control: Eradication}$

$\text{Control of Invasive Species}$
Alternative Perspective

Invasive Species Population Size

Total Control Costs

Marginal Control Cost (MCC)

Marginal Damage (MD)

Net Benefits

Total Damages

Zero Population Size

Control level

Maximum Population Size

Invasive Species Population Size
Benefit Estimation Methods

- Revealed Preference—inferrred from behavior
  - Travel Cost Model
    - Measure the value of improved recreational fishing if sea lamprey populations are suppressed (Lupi et al., 2003)
  - Hedonic Property Value Model
    - Eurasian watermilfoil effect on lakeshore property values (Horsch and Lewis, 2009)
  - Averting Expenditure
    - How much is spent to avoid effects? (water quality: Abdalla et al. 1992)
- Stated Preference—inferrred from survey responses
  - Survey to ask willingness to pay for delay of effects of invasive species (McIntosh et al., 2010)
- Producer Welfare Model
  - Costs to power plants and water treatment plants of zebra mussels (Connelly et al., 2007)
Using an Economic Model of Recreational Fishing to Evaluate the Benefits of Sea Lamprey (*Petromyzon marinus*) Control on the St. Marys River

Frank Lupi, John Hoehn, and Gavin Christie 2003

**FIG. 1.** Steps required to link treatment options to economic value.
Total Benefits to Michigan Anglers in 2015

- Annual Sterile Male Release & Trapping
- Annual Sterile Male Release & Trapping plus Bayluscide once
- Annual Sterile Male Release & Trapping plus Bayluscide every five years

Estimated Absolute Trout Population Increase
(thousands of mature lake trout)
Further Results

- **Baseline:** current trout population
- Measures stream of benefits/costs to find Net Present Value of three options
  - NPV > 0 for all
  - Recommendation is sensitive to discount factor
- **Value:** just value of *recreational fishing* for trout
- **Stewart et al.** (2003) point out that you could add:
  - existence value by non-fishing population
  - Value to anglers outside of Michigan
Quantify the annual and cumulative economic impact of zebra mussels, from the first full year after their introduction (1989) to 2004.

“Annual costs were greater ($44,000/facility) during the early years of zebra mussel infestation than in recent years ($30,000).”
ZM damage estimates:

- Zero Control: Maximum Population Size
- Maximum Control: Eradication

Marginal Benefit

Marginal Control Cost?

Damages incurred: $267 million
Lost revenue, treatment costs
Invasive species and delaying the inevitable: Valuation evidence from a national survey
McIntosh, Shogren, and Finnoff 2010

- Stated Preference for avoiding high damages: TOTAL

<table>
<thead>
<tr>
<th>Delay of Invasion</th>
<th>No Delay</th>
<th>Ten Year Delay</th>
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<td>$5.5 billion</td>
<td>$25.4 billion</td>
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Wrap up

- In principle, evaluate the full range of benefits and costs to be able to identify the optimum.
- In practice, identify and evaluate several scenarios, including benefits and costs
- Possible pitfalls:
  - Assuming constant marginal benefits
  - Ignoring the possibility of adaptation/mitigation
  - Using information about public expenditures incorrectly
- Beyond cost/benefit
  - Uncertainty
  - Irreversibility
  - Bioeconomic modeling
  - Spatial economics
Genetic Biocontrol Costs:

- **Control of Invasive Species**
- **Maximum Control**: Eradication
- **Zero Control**: Maximum Population Size

Graph showing the costs of genetic biocontrol compared to conventional methods. The x-axis represents control levels ranging from zero control to maximum control, and the y-axis represents cost. The graph includes lines labeled MB, Conventional MCC, Genetic Biocontrol MCC', and an area representing the cost savings of genetic biocontrol.
Genetic Biocontrol Costs:

Control of Invasive Species

$\text{Control}$

$\text{Zero Control: Maximum Population Size}$

$\text{Maximum Control: Eradication}$

$\text{Conventional MCC}$

$\text{MB}$

$\text{Genetic Biocontrol MCC'}$
Conventional control:

Conventional MCC

Genetic Biocontrol MCC’

$\text{MB}$
Changes in costs

$\text{Zero Control: Maximum Population Size}$

$\text{Maximum Control: Eradication}$

$\text{Control of Invasive Species}$

$MB$

$\text{Reduced cost}$

$\text{Additional cost}$

$\text{Additional net benefit}$

$\text{Genetic Biocontrol MCC'}$

$\text{Conventional MCC}$
Other things to think about

- Streams of benefits and costs: up front costs, long term benefits (NPB criterion)
- Irreversibility: the possibility of a bad outcome
  - Adding a hurdle in order to make taking the step worthwhile (Fenichel et al.)
Back of the Envelope Methods

- Control expenditures by public agencies
- Control expenditure per unit controlled
- Average value multiplied by some number
  - e.g., value per lake trout multiplied by increased number of lake trout brought about by management
  - Cost per power plant affected by zm multiplied by number of power plants affected, forecast into the future
Issues...

- Dynamics
  - Accounting for population growth
  - Discounting
  - Changing costs of control with new technology, etc.
  - $\lambda(t)$—marginal benefit of removing invasive today, accounts for future growth, management, etc.

- Uncertainty
- Spatial factors
- Relevant Scope
Economic Injury Level used for sea lamprey

- Population level which:
  - Minimizes total cost = fishery management cost + lamprey control cost + damage by lamprey
  - Subject to: trout at target population level
- Where is extra control cost not justified by extra benefit?
- Economic damage proportional to trout mortality
Leigh, 1998

- Baseline: no control of ruffe
  - Projected population in all Great Lakes
  - Effects on sportfish populations (yellow perch and walleye)
- Control Program
  - Projected population of ruffe
  - Projected sportfish populations
  - Effect on recreational fishing—angler days (value from existing contingent valuation study)
  - Consumer Surplus to anglers from improved fishing
  - Effects on commercial and sportfishing industry
  - Avoided Damages: benefits
  - Three scenarios evaluated to account for uncertainty