Valuing Changes in Aquatic Ecosystem Services from Reductions in Nutrient Loadings: A Methodology for Linking Environmental Benefits and Economic Valuation

Carol Mansfield

RTI International

Presented at NCER 2013

Chicago, IL

Acknowledgments

Co-investigators

- Dan Phaneuf (University of Wisconsin)
- George Van Houtven (RTI)
- Roger von Haefen (NC State University)
- Melissa Kenney (Johns Hopkins University)
- Ken Reckhow (CardnoENTRIX and Duke University)

Funding

- Grant #X7-83381001-0 from the U.S. Environmental Protection Agency, Office of Water. Information contained in this report represents the opinion of the authors and does not necessarily represent the views and policies of the Agency.

Project Objectives

- Design and deploy a rigorous, accessible, and transferable protocol to allow:

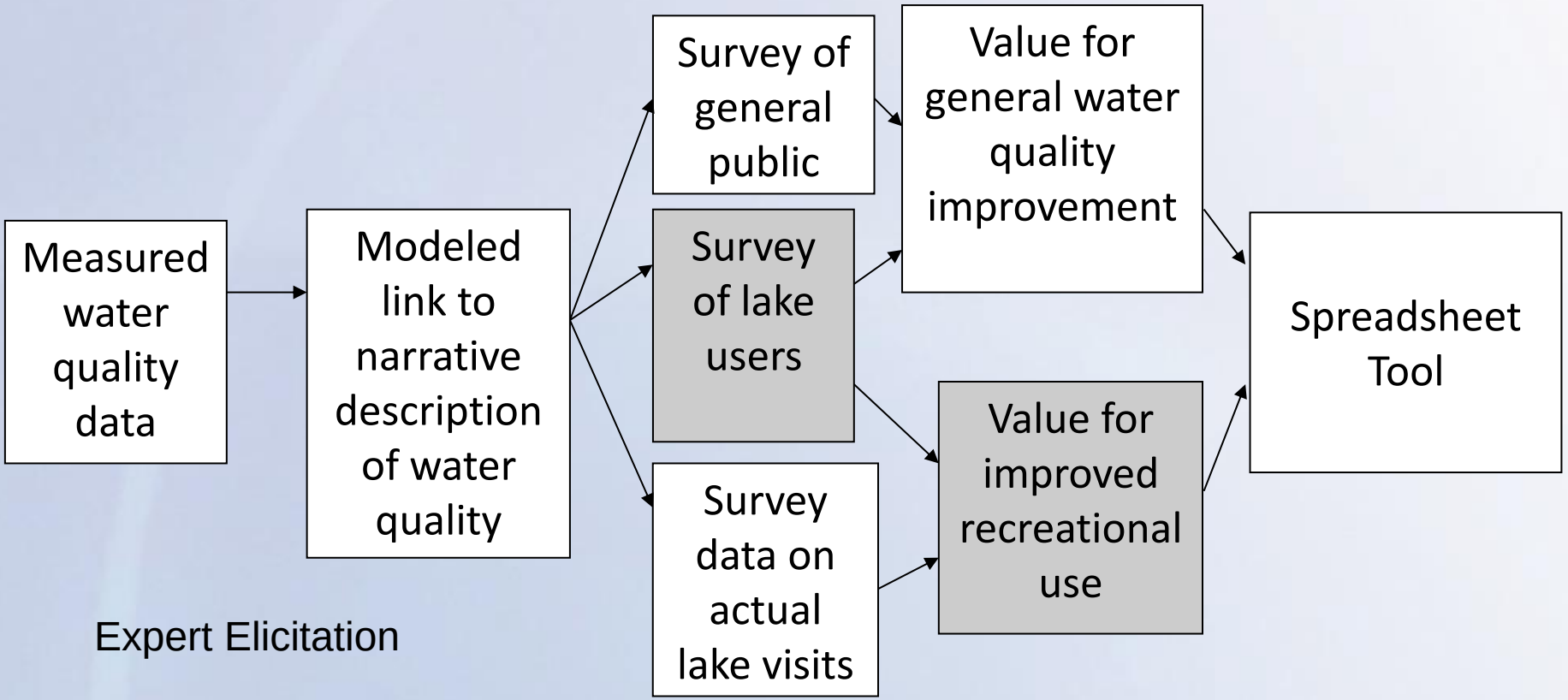
Ambient water quality as given by a numeric indicator (e.g. 40 μg/ml chlorophyll a)

Dollar-denominated aggregate benefits of water quality improvement relative to a status quo.

Key challenges:

- A method for mapping nutrient parameter values to "things people care about" (indicators of ecosystem services)
- A method for mapping "things people care about" to economic values

Overview of Research



Mapping Water Chemistry to the Eutrophication Index

- Expert Elicitation: 14 water quality experts were presented with the same 100 rows of water chemistry data, each representing a different lake in North Carolina.
  - total nitrogen, inorganic nitrogen, phosphorous, chlorophyll *a*, dissolved oxygen, secchi depth, photic turbidity
  - Elicitation Task:

  Imagine 100 different lakes with the characteristics specified by the given data row. Of the 100 lakes, how many of the lakes would you expect to fall into each of the following five categories of eutrophication?
- Estimated ordered logit, SEM to create functions linking numeric measures to probability in a given category
- If you have enough data, don't need expert elicitation

Trophic Status Category

	Water clarity	Color	Algae	Nutrient levels	Oxygen	Odor	Aquatic life
1	Excellent	None	Very little	Very low	Very high	No	Very healthy
2	Good	Little	Little	Low	High	Little	Healthy
3	Fair	Some	Mod	Mod	Mod	Little	Some-what healthy
4	Poor	Notice-able	High	High	Low	Notice-able	Un-Healthy
5	Poor	Consider-able	Very high	Very high	Low to no	Strong offen-sive	Un-Healthy

Stated-Preference Survey

- Big challenge in valuing ecosystem services is how to match services with chemical/physical measurements and to “things people care about”
- Create survey questions that build on narrative categories used in expert elicitation
- Design descriptions that make sense to the public and are true to what scientists were thinking

Description of Lake Eutrophication Categories

CATEGORY	A	B	C	D	E
Color	Blue	Blue/brown	Brown/green	Brown/green	Green
Clarity	Can see 5 feet deep or more	Can see 2–5 feet deep	Can see 1–2 feet deep	Can see at most 1 foot deep	Can see at most 1 foot deep
Fish	Abundant game fish and a few rough fish	Many game fish and a few rough fish	Many rough fish and a few game fish	A few rough fish but no game fish	A few rough fish but no game fish
Algae blooms	Never occur	Small areas near shore; some years, 1–2 days	Small areas near shore; most years, 1 week	Large areas near shore; once a year, 2–3 weeks	Large, thick areas near shore; every year, most of summer
Odor	No unpleasant odors	1–2 days a year, faint odor	1–2 days a year, faint odor	3–4 days a year, noticeable odor	Several days a year, noticeable odor

Color

Blue

Blue / Brown

Brown/Green

Green

Household Survey

- Stated Preference Survey: Knowledge Networks Web Panel
  - Sample: N=1,327 from NC, SC, VA, KY, TN, GA, AL, MS

- Key Survey Components
  - Questions about respondent's lake recreation activities
  - Description of causes and attributes associated with lake eutrophication
  - Choice question (conjoint): recreation lake choice
    - Varied water quality, driving distance
  - Contingent Value question: improving water quality in all lakes in state

Example Choice Question in Survey

		Lake 1	Lake 2
WATER QUALITY	WATER QUALITY CATEGORY	A	C
	COLOR	Blue	Brown/Green
	CLARITY	Can see 5 feet deep or more	Can see 1-2 feet deep
	FISH	Abundant game fish and a few rough fish	Many rough fish and a few game fish
	ALGAE	Never occur	Small areas near shore; most years, 1 week
	ODOR	No unpleasant odors	1-2 days a year, faint odor,
ONE WAY DISTANCE FROM YOUR HOME		60 minute (1 hour) drive	40 minute drive
Which lake would you choose?		○ Lake 1	○ Lake 2

RTI INTERNATIONAL

Conditional Logit Coefficients and Z-statistics

	Model I
Opt out	−3.491
	(−27.2)
Price	−0.017
	(−15.18)
Water Quality (1=best, 5=worst)	−0.765
	(−27.45)

Marginal value 1 unit change in water quality (std. error)	**$44.84 (2.62)**

Water Quality Benefits Spreadsheet

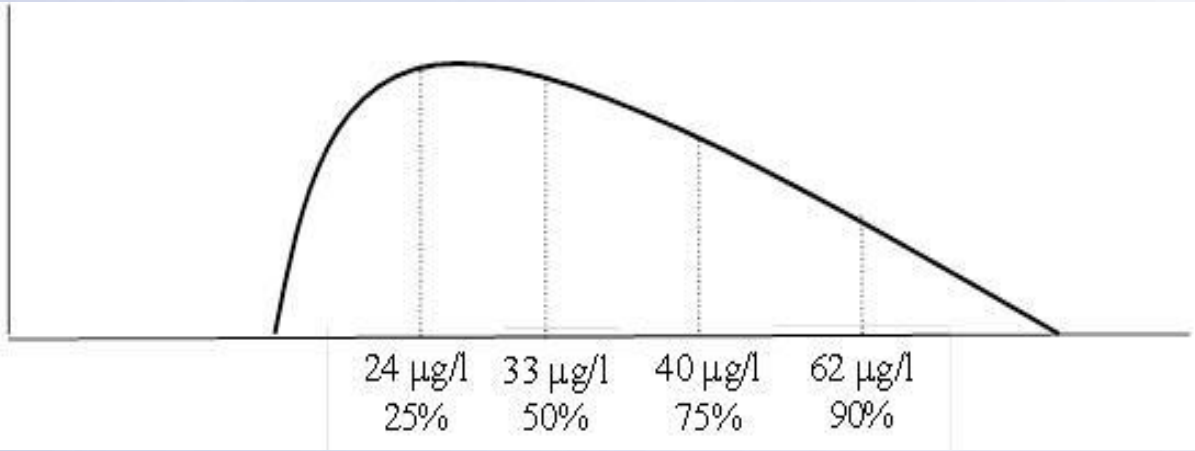
Baseline Data	Nutrient Target(s)	Information
Required: Total Nitrogen (mg/l) Total Phosphorous (mg/l) Chlorophyll a (mg/l) **Useful But Not Required:** Secchi Depth (m) Turbidity (NTU)	Total Nitrogen (mg/l) Total Phosphorous (mg/l) Chlorophyll a (mg/l) Secchi Depth (m) Turbidity (NTU) **Other** Trips per year Time Horizon (Years) Discount Rate	**Summarized** WTP per Trip Aggregate Annual WTP NPV of Annual WTP Baseline WQ Index Counterfactual WQ Index
Baseline Inputs	**Policy Inputs**	**Model Outputs**

Falls Lake, NC, Case Study

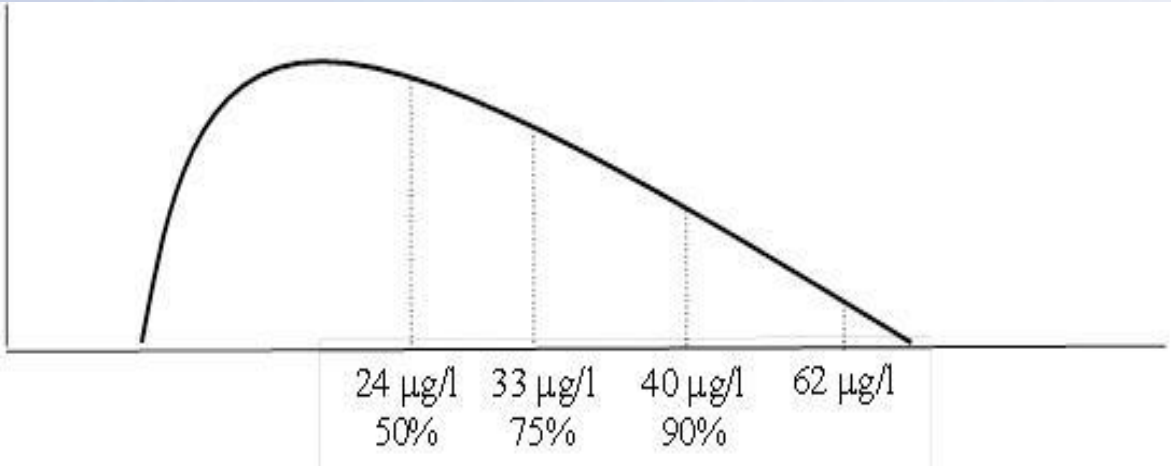
- NC wants to reduce nutrient levels in reservoirs
  - Discussed setting a nutrient criterion such that no more than 10% of *chlorophyll a* readings are over 40 mg/l.
  - Under baseline conditions 10% of readings are over 62 mg/l.

- Used Water Quality Benefit Spreadsheet to calculate total value of change to recreational lake users

Baseline and Policy Scenarios, chlorophyll a



2006 baseline, median 33 mg/l



Distribution with policy, median 24 mg/l

Values for Key Nutrient Parameters

	2006 Baseline Medians and (Means)	Policy Medians
Total nitrogen (TN)	0.76 (0.79) mg/l	0.70 mg/l
Total phosphorus (TP)	0.05 (0.07) mg/l	0.048 mg/l
Chlorophyll a (CLA)	33.00 (35.80) mg/l	24.00 mg/l
Secchi depth (S)	0.70 (0.70) m	0.74 m
Turbidity (T)	9.65 (14.06) NTU	9.05 NTU

Spreadsheet model predicts Policy Medians based on chlorophyll a

Results

Baseline water quality index	3.45 between levels C and D
Policy water quality index	3.15, approximately level C
Average per-trip WTP for change in water quality	$15.29
Number of recreational trips per year	0.9 million
Annual benefits	$13.76 million
Benefits over 20 years (5% discount rate), the present value of the stream of benefits	$171.52 million

- Refinements available: phase in water quality improvements, change visitation as water improves

Conclusion

- Method to link physical/chemical readings with valuation survey when data sparse
- Applicable to many situations

- Spreadsheet calculator, user manual and technical reports coming soon to:

http://www.epa.gov/nandppolicy/links.html, and clicking on the ‘grants’ folder