IMPROVING META-ANALYSIS AS A PRACTICAL TOOL FOR VALUING ECOSYSTEM SERVICES

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Benefit Transfer in Economic Analysis of Environmental Regulations

- Cost benefit analysis of environmental regulations rarely affords time and money to conduct primary valuation research
- Benefit transfer (BT) is often the only remaining option for valuing changes in ecosystem services
- Function-based transfers typically outperform unit-value transfers
- BT based on meta-regression models (MRMs) have been increasingly used in years in policy analysis
  - MRMs allow to predict economic values for ecosystem changes at policy sites, based on site characteristics and expected environmental changes
  - Numerous MRMs have been published in recent years
  - MRMs have the potential to generate robust, accurate and broadly applicable benefit functions.

Benefit Transfer in Economic Analysis of Environmental Regulations

- MRMs of surface water valuation studies :
  - Developed for § 316b regulations under Clean Water Act
    - Johnston et al. (2005)
  - CWA effluent limitations guidelines (ELGs) and standards for Construction and Development (C&D);
    - 2005 MRM updated based on new studies (U.S. EPA, 2009)
  - Water quality standards for Florida's estuaries, coastal water, and South Florida inland flowing waters
  - ELGs for Steam Electric power generating sources (proposal)
  - Regulation of stormwater discharges in urban areas

Typical Structure of MRMs: Surface Water Quality

Dependent Variable : WTP for water quality improvements

Independent variables:	Available from original studies?
Study methods	Yes
Population	Yes
Water body type	Yes
Water quality change	Yes
Market extent	Categorical values
Substitute sites	Categorical values/proxies
Spatial resource characteristics	Categorical values

Core Geospatial Variables Needed for BT

Resource Characteristics

- **Used in MRMs:**
- Small/large
- Single vs multiple water bodies
- **Needed:**
- Quantitative measures of water body size (e.g., river miles)

Market Extent

- **Used in MRMs:**
- Regional
- National
- State-level
- **Needed:**
- Explicit area/distance metrics

Substitute Effect

- **Used in MRMs:**
- Presence/absence
- Proxies
- **Needed:**
- Explicit/quantitative measure

No published MRMs incorporate a full set of quantitative measures needed for developing BT estimates tailored to policy scenarios.

Why Geospatial Variables Matter?

- Need to account for distance decay effect (Bateman et al. 2006):
  - Larger sampled market areas (e.g., states versus watershed) relative to the affected resource → smaller mean per household WTP estimates (Johnston and Duke 2009).
- WTP is inversely related to the quantity of unaffected substitute resources in close proximity (Schaafsma et al. 2012).

Implications for Benefit Transfer

- Existing MRMs predict the **same per household WTP** for a given water quality change, regardless of the **water body size**, the extent of **market area**, or presence of **substitute sites**
  - Per household estimates that do not correspond to economic theory
  - Policy analysts use ad hoc adjustments to address models limitations
  - Potential to bias benefit estimates

New Generation MRM

- Meta data: 140 observations from 51 stated preference studies conducted between 1981 and 2011
- Dependent variable: natural log of household WTP for water quality improvements measured on standard 100 point water quality index
- 24 independent variables characterizing: (1) study methodology, (2) populations, (3) **water bodies**, (4) **market areas**, (4) **substitute sites** (5) water quality
- 20 coefficients statistically significant at $p<0.10$
- Outperforms restricted model that omits core geospatial variables

Revised vs Existing MRMs

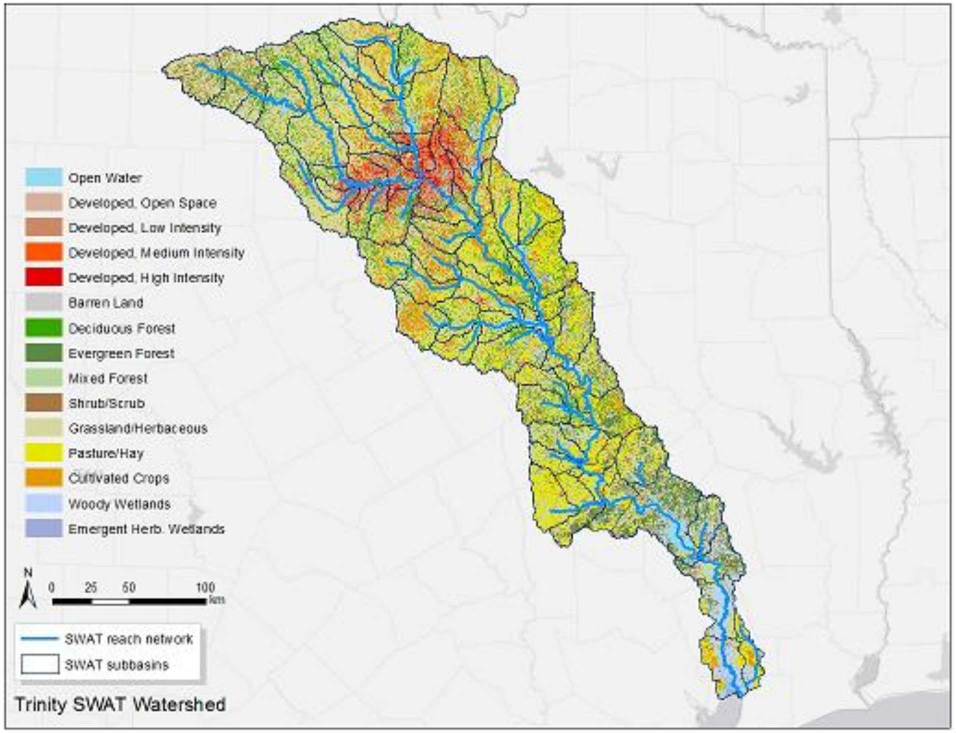
- **Two alternative market extent variables:**
  - The measure of geospatial scale(***ln_ar_ratio***) is defined as (natural log of the) size of the sampled market area (sa_area) divided by the total area of counties that intersect with the affected water bodies (*ar_total_area*).
  - Index of geospatial scale and market extent: **ln_rel_size** = log of (total affected shoreline [km] divided by total sampled market area [km2]).
- **Substitute effect :**
  - **sub_frac** = proportion of water bodies of the same hydrological type affected by the water quality change, within affected state(s).
    - For lakes measured as proportional surface area.
    - For rivers and bays measured as proportional shoreline.

Results for Core Environmental & Resource Variables

Variable	Coefficient Estimates	Standard Errors
Ln_ar_ratio	-0.073	(0.025)***
Sub_frac	0.668	(0.181)***
ln_ar_agr	- 0.392	(0.091)***
lnquality_ch	0.299	(0.106)***
lnbase	-0.036	(0.123)

Case study : WTP for Water Quality Improvements in Trinity Watershed , TX

- River Miles: 1,688 miles
- Expected to improve: 1,514 miles (90%)
- Average BL WQI : 53.8
- Average ∆ WQI :1.4
- Market Extent:
  Ln_ar_ratio = -0.492
- Substitute effect:
  Sub_frac = 0.15
- Households: 3.4 million



Results for Alternative Model Specifications

Models	Per Household WTP	Total WTP (Millions)
New Generation MRM	$49.07	$164.2
MRM without Geospatial Variables - No Adjustment	$74.09	$247.97
MRM without Geospatial Variables WTP Adjusted based on *sub_frac*	$11.41	$39.1

Conclusions

- Geospatial and substitution effects alone have substantial effects on the estimated WTP value.
- Using ad hoc adjustments to account for omission of geospatial variables in existing MRMs is likely to understate benefits of water quality improvements
  - Incorporating substitute effect in the model as opposed to ad hoc adjustments increases total WTP 4 times from $39.1 million to $164 million
- The use of benefit function transfers that ignore geospatial characteristics may lead to biased estimates of benefits of water quality improvements