Valuing Water Quality for Integrated Assessment: Challenges and Progress

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VALUING WATER QUALITY – GENERAL CONSIDERATIONS

Value generating mechanism(s):

- Recreation
- Residential amenity
- Drinking water provision
- Health risks
- Nonuse/indirect use

Value generating commodity:

- Ambient pollution (e.g. nutrient concentration)
- Supporting uses (swimming, fishing, boating, etc.)
- Ecological endpoints

→ defining the entity over which people have preferences

General Considerations Continued

Spatial extent of valuation

- Local neighborhood
- day trip length
- endogenously determined

Measurement:

- RP or SP
- Marginal or non-marginal (discrete change) valuation objective(s)
- Validity

Etc.

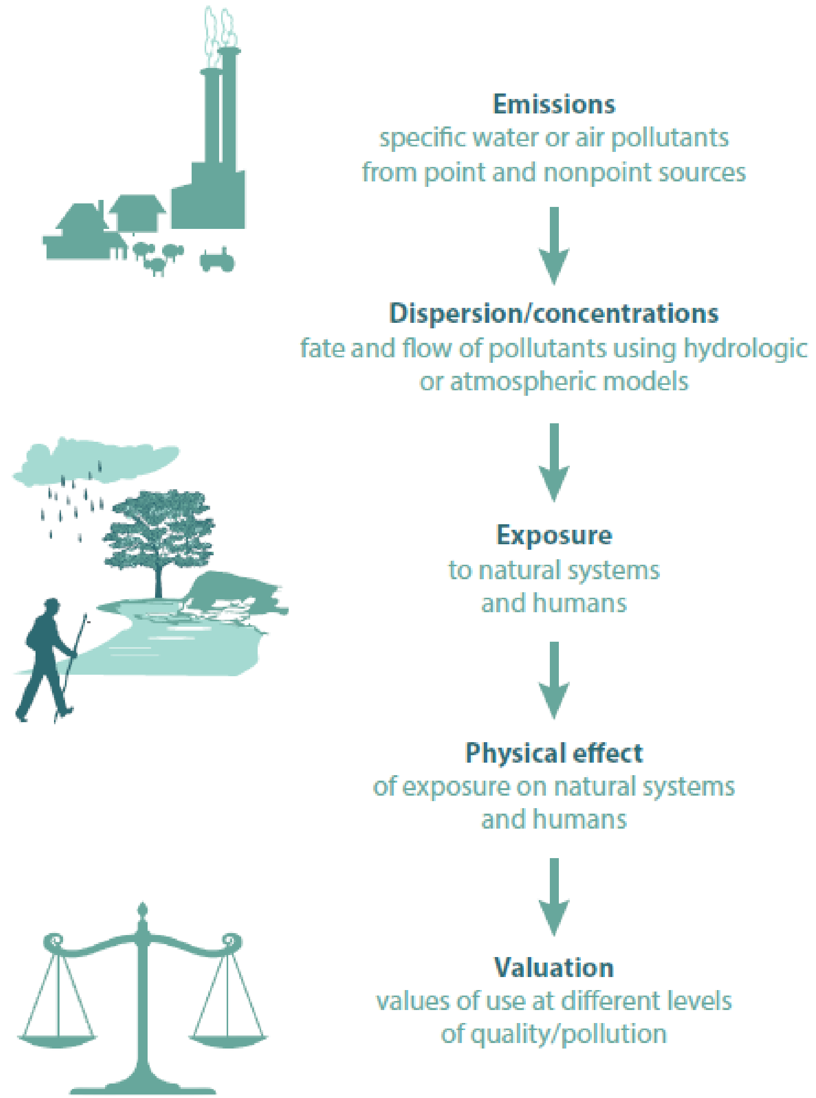
These considerations are also relevant for the specific case of IAMs

VALUING WATER QUALITY – INTEGRATED ASSESSMENT

Keiser and Muller (2017):

- Valuation component of IAMs needs to be compatible with other elements.

How to make the contextual richness of water quality valuation (a square peg) fit with the needs of IAM (a round hole)*?*



Valuation Needs to Be…

Reducible – valuation concept needs to boil down to a simple (unidimensional?) summary

Scalable – valuation concept needs to have meaning in individual, population, and spatial aggregate contexts.

Portable – measurements need to make conceptual and empirical sense across the study landscape

Linkable – valued commodity needs to be functionally related to ambient water quality and ultimately emissions

Basic challenge: designing a valuation component that is 'RSPL' but reflective of important spatial, ecological, and population heterogeneity

Conceptual Basis

Define the IAM 'study area' as follows:

- j=1,…,J waterbodies
- q_j – ambient water quality endpoint for waterbody j with $q=(q_1,\ldots,q_J)$
- e_k – pollution loading into waterbody k with $e=(e_1,\ldots,e_J)$
- $q=q(e)$ – hydrology connecting loadings in space to quality in space
- n=1,…,N places where people level
- i=1,…,I people with population I_n in each place. $I=\Sigma I_n$ and α_i denotes observable heterogeneity
- $V_i(p,q,y_i;\alpha_i)$ – indirect utility defined over market prices (p), water quality, income (y), for household type α_i

Landscape is fully defined by *J*, *N*, *I*, *q*(*e*)

MARGINAL VALUES FOR Δe_k

Physical change in quality

$$\Delta q_j = \frac{\partial q_j(e_1, \ldots, e_J)}{\partial e_k} \times \Delta e_k, \quad j = 1, \ldots, J.$$

Individual MWTP

$$MWTP_{ij} = \frac{\partial V_i / \partial q_j}{\partial V_i / \partial y} \times \Delta q_j$$

Landscape wide value

$$B(\Delta e_k) = \sum_{i=1}^{I} \sum_{j=1}^{J} \frac{\partial V_i / \partial q_j}{\partial V_i / \partial y} \times \Delta q_j$$

Core Valuation Challenge

Empirical realization of

$$MWTP_{ij} = \frac{\partial V_i(p, q, y_i; \alpha_i)/\partial q_j}{\partial V_i(p, q, y_i; \alpha_i)/\partial y}$$

which:

- accommodates **population, ecological, other spatial** heterogeneity
- is **unidimensional** but **broadly reflective** of multiple valuing generating mechanisms

A STATED PREFERENCE APPROACH

Biological condition gradient (BCG) – ordinal ranking of aquatic ecosystem health based on local baseline

- "*a framework to describe incremental change in aquatic ecosystems*"
- *"… [different approaches to assess biological condition] have fostered innovation [but have] complicated a nationally consistent approach to interpreting the condition of aquatic resources.*"

  → BCG designed to be broadly applicable across space, incremental, unidimensional, reflective multiple ecological indicators

Possible to use BCG scores for waterbodies as value generating commodity in a total value stated preference framework?

The Biological Condition Gradient: Biological Response to Increasing Levels of Stress

Levels of Biological Condition

Level 1. Natural structural, functional, and taxonomic integrity is preserved.

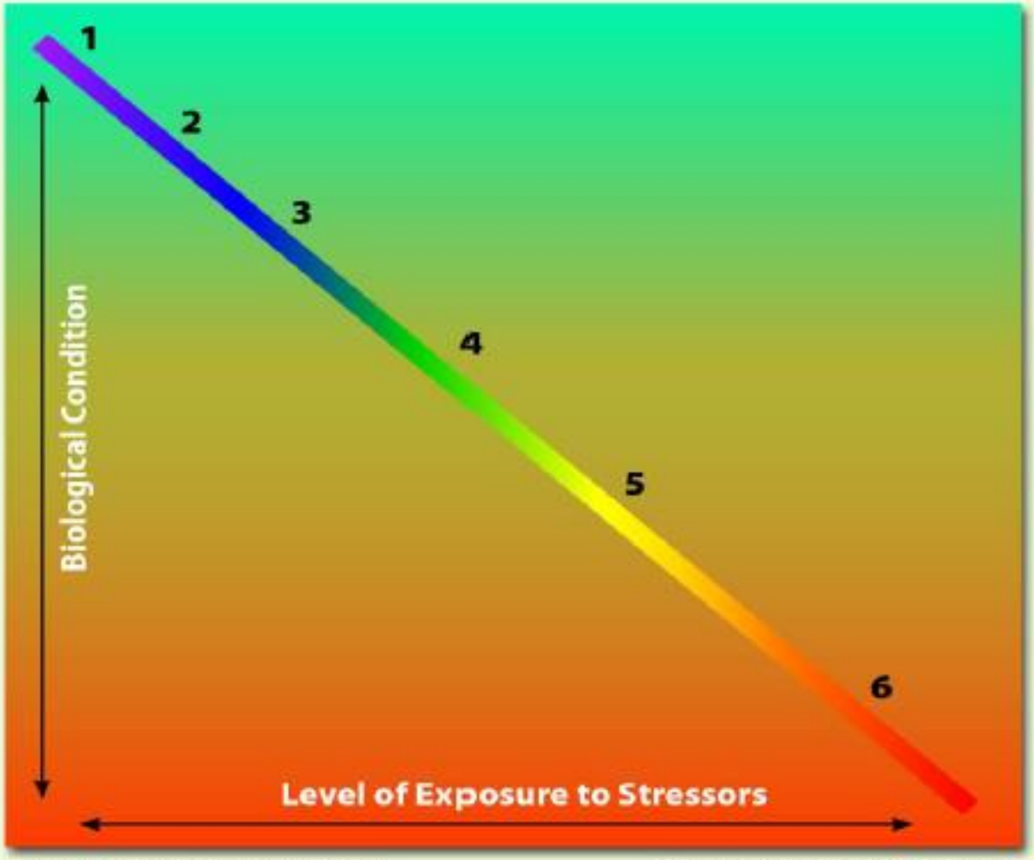
Level 2. Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

Level 3. Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Level 4. Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Level 5. Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

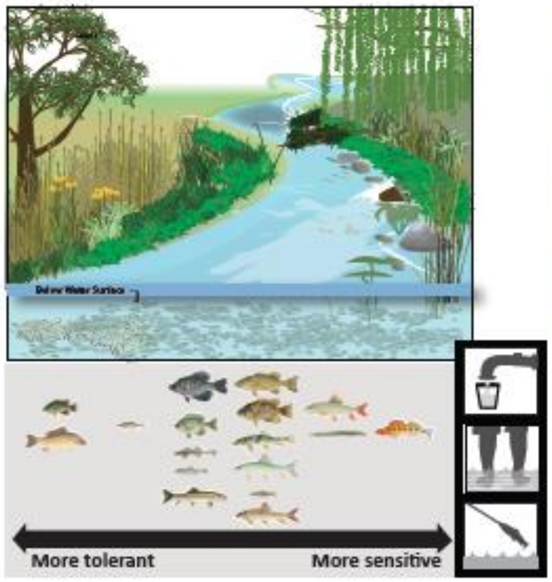
Level 6. Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.



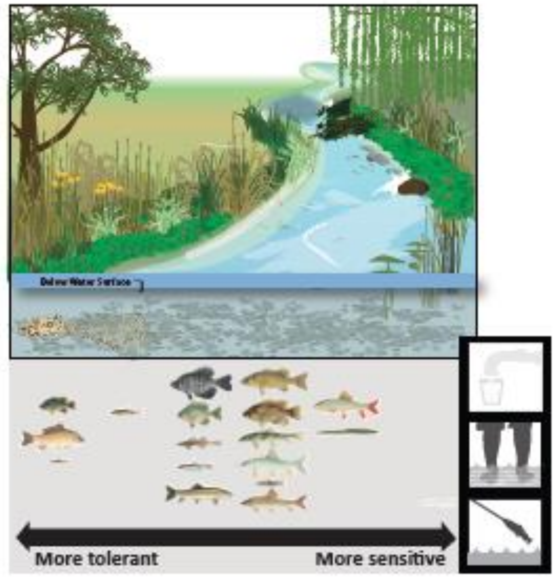
Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.

Level 1



Level 2



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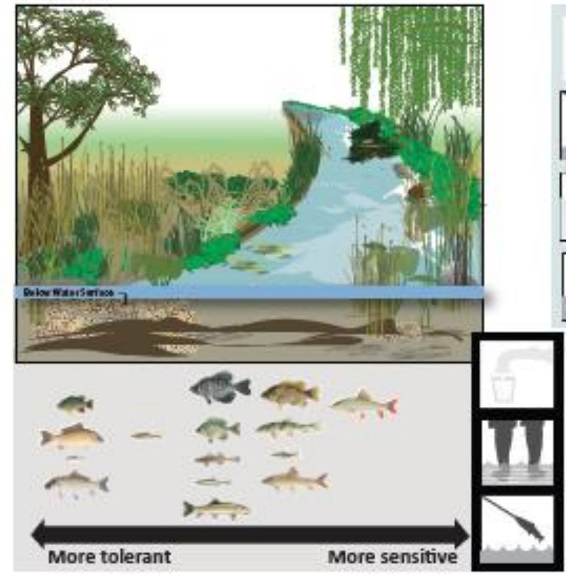
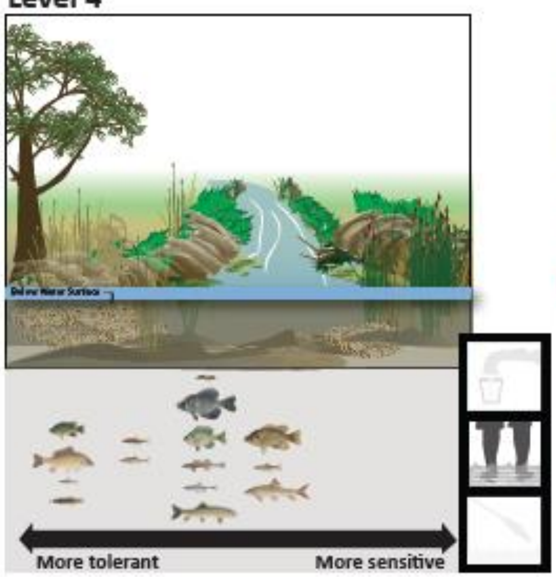
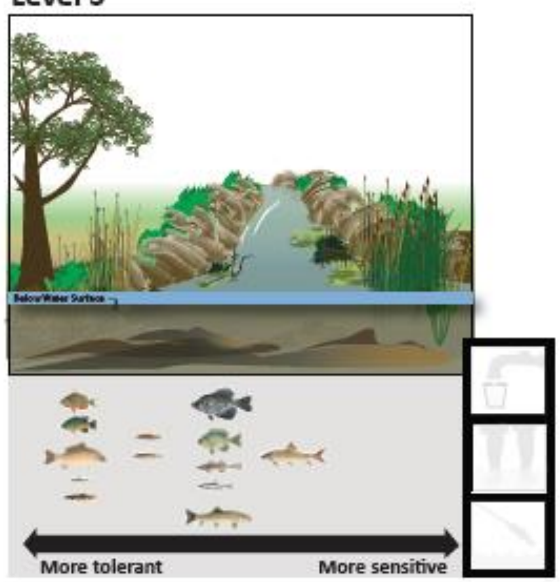


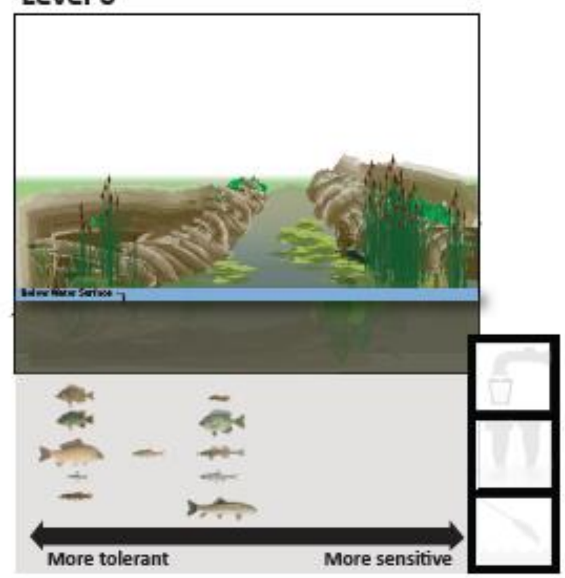
Level 4



Level 5



Level 6



Necessary steps:

- Estimate ‘total value’ marginal WTP for ΔBCG_j in waterbodies j=1,…,J among representative population conditional on observable characteristics α_i

  → α_i (also) indexes ‘place’ n where household lives

  → address ‘spatial extent’ problem

- For place n in landscape:

$$mWTP_{nj} = I_n \times \int \frac{\partial V_i(\alpha_i)/\partial q_j}{\partial V_i(\alpha_i)/\partial y} \times f_n(\alpha) d\alpha$$

- Connect Δe_k to ΔBCG_j for all j

- For a loading scenario sum $mWTP_{nj}$ for ΔBCG_j across places and waterbodies