Measuring BRIs Using Ecological & Social Context

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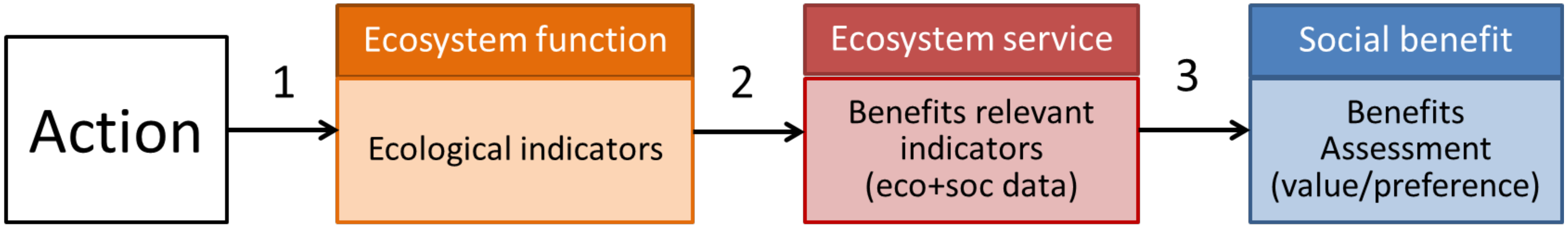
Outline

1. Review BRI definition
2. How end uses of BRIs inform their development
3. Creating & measuring BRIs
4. Examples and methods for overcoming data gaps
5. Aggregation and other analytic considerations
6. Sources of additional information
7. Group exercise – Developing BRIs

What are Benefit Relevant Indicators (BRIs)



- Measurable indicators that capture the connection between ecosystems and people
- The point of hand off between ecologists and economists – that combine ecological and social information
- A complement or stepping stone to valuation or an alternative

BRIs identify conditions under which an ecological change is likely to be valued

Ecosystem Service Opportunities

Biophysical changes

- Δ wave height
- Δ water quality
- Δ habitat
- …

BRIs →

Human Well-Being Outcomes

Health & Safety

- Home protection
- Food production
- Water supply
- …

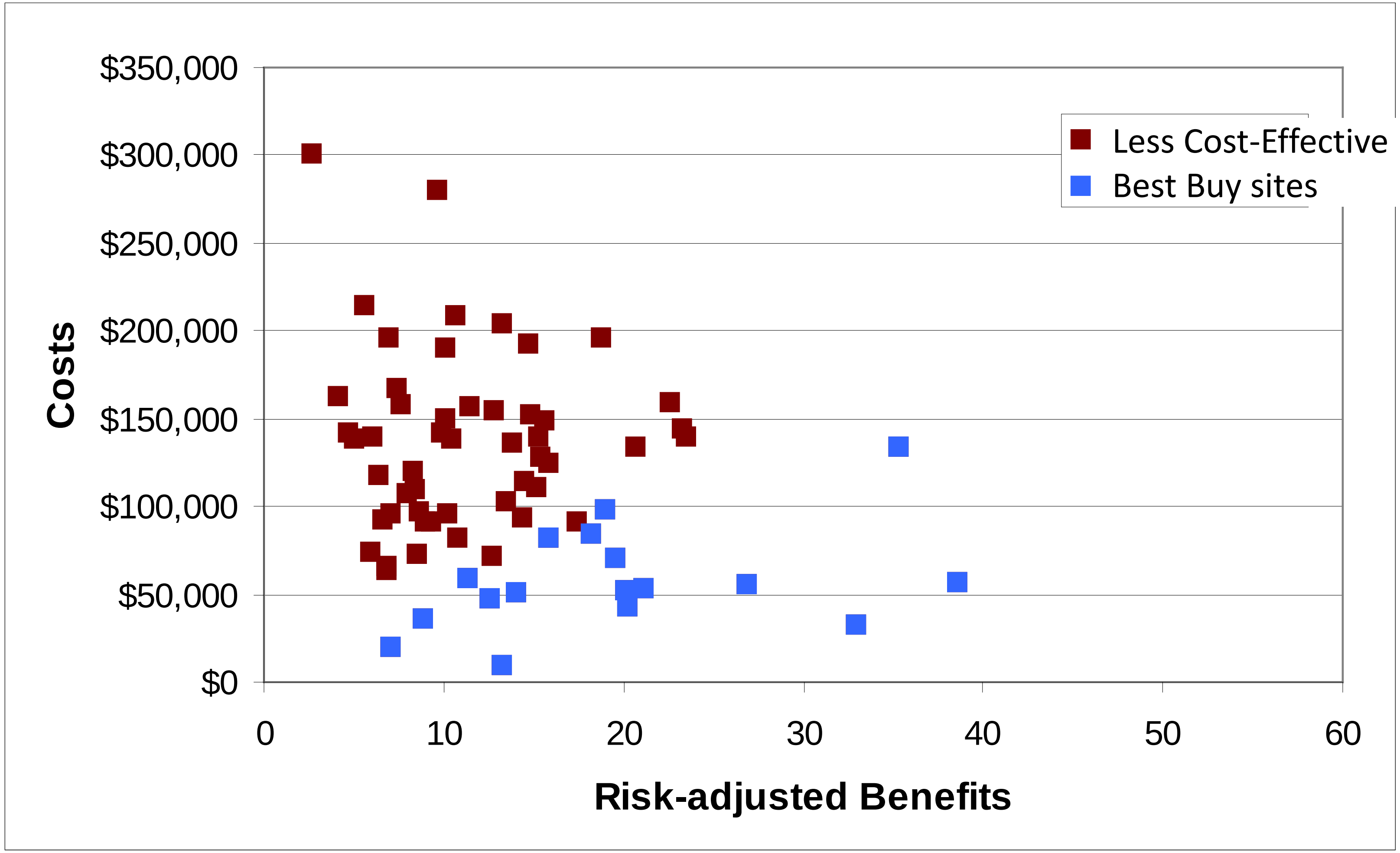
Fulfillment

- Recreation
- Satisfaction of environmental stewardship
- …

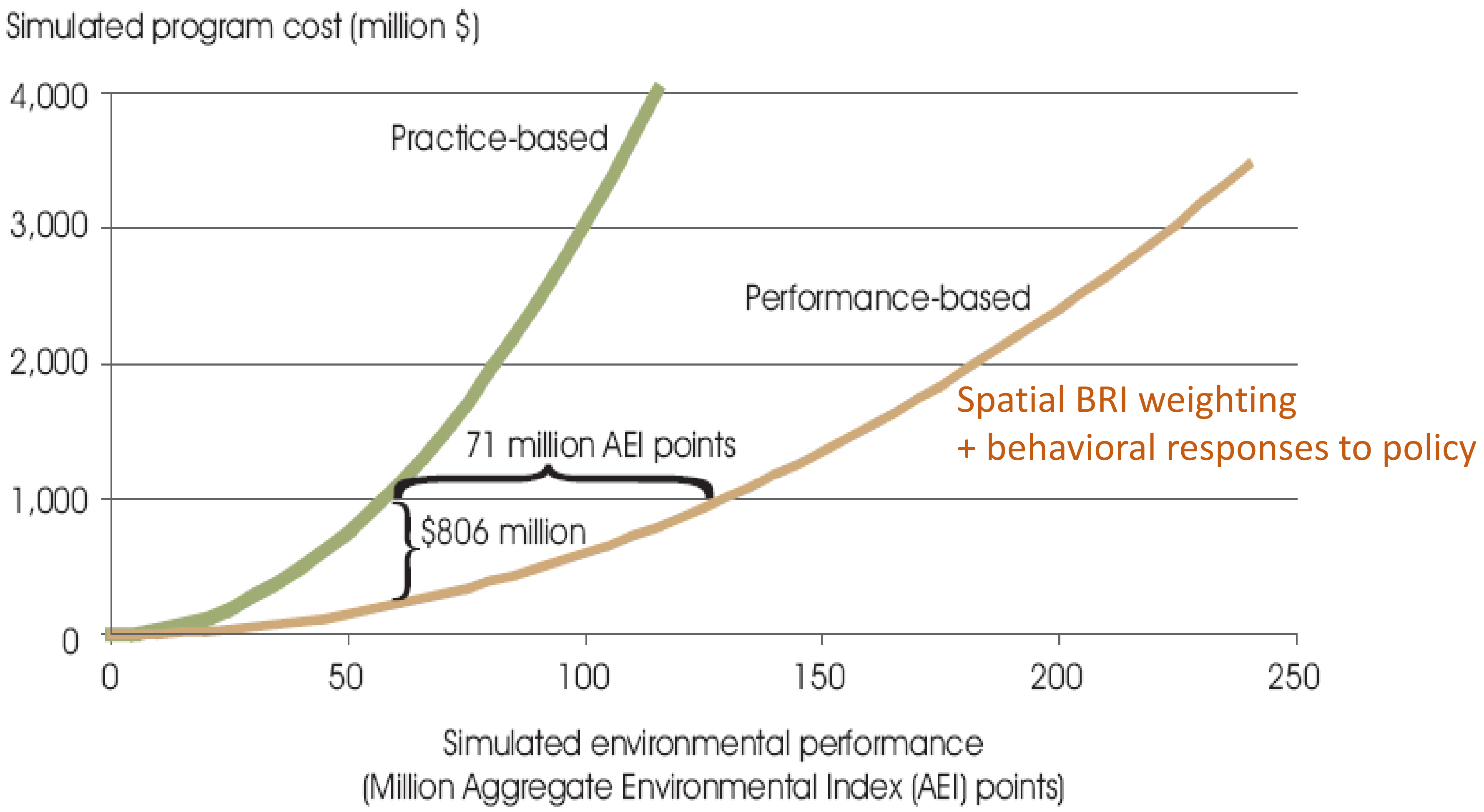
How are BRIs Used?

1. Quantitative Communication
   - Summarize impacts in quantitative units
   - *Tons CO2e sequestered* ⟷ *Number of homes protected*
2. Cost Effectiveness Analysis
   - Uses a single metric or index to compare performance
   - *2 lives saved / $1 spent*
3. Multi Criteria Decision Analysis
   - Preference-weighted and normalized benefits
   - *20 points of recreation benefits* (relative units)

Cost-Effectiveness Analysis
BRI Goal: Generate performance metric for comparing alternatives

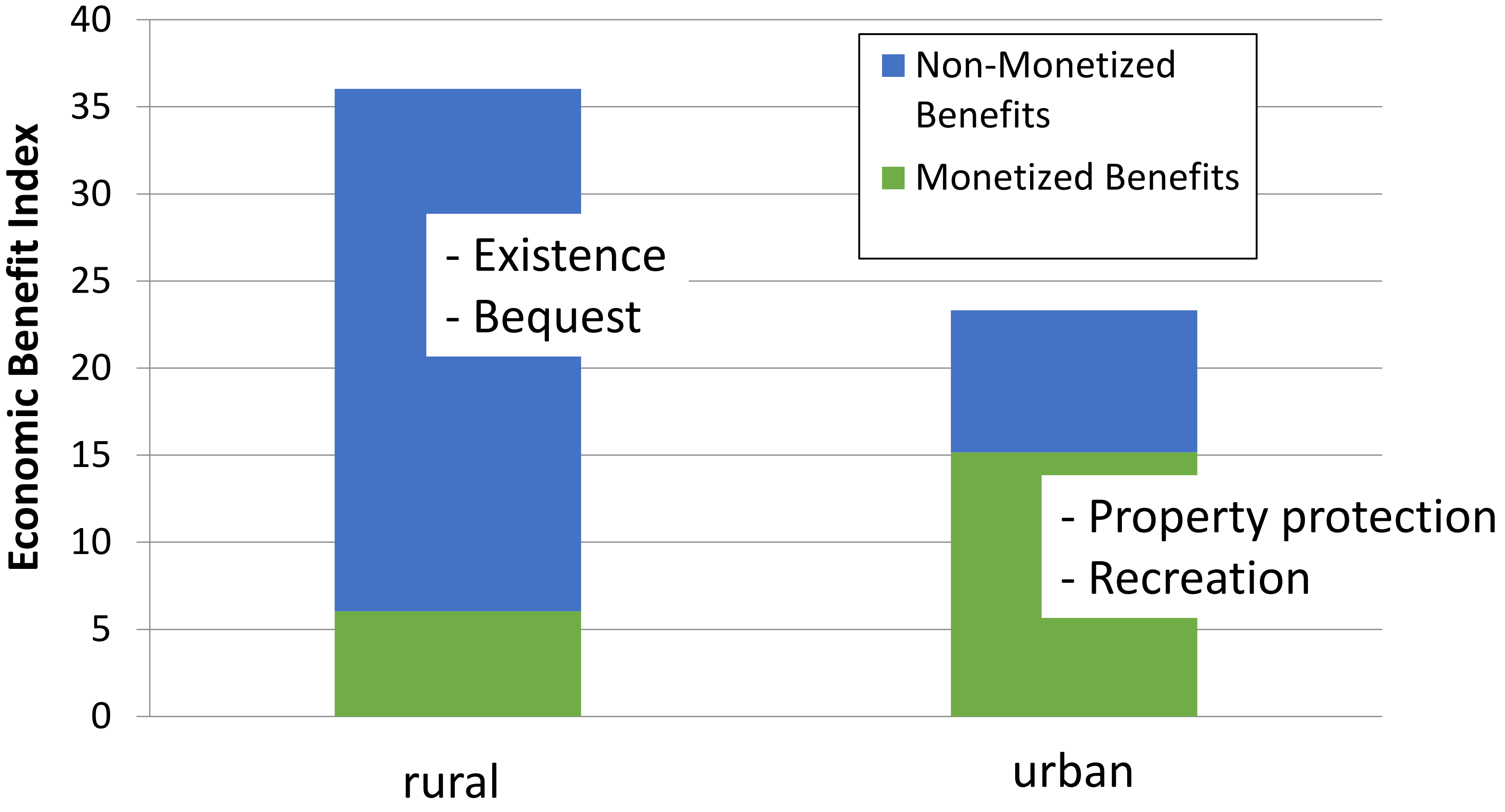


BRI goal: Enhance cost-effectiveness of decisions



Weinberg and Claassen, March 2006 USDA ERS Economic Brief

BRI goal: Provide inclusive view of benefits



Creating BRIs that match end uses

1. Complement
2. Stepping stone
3. Alternative

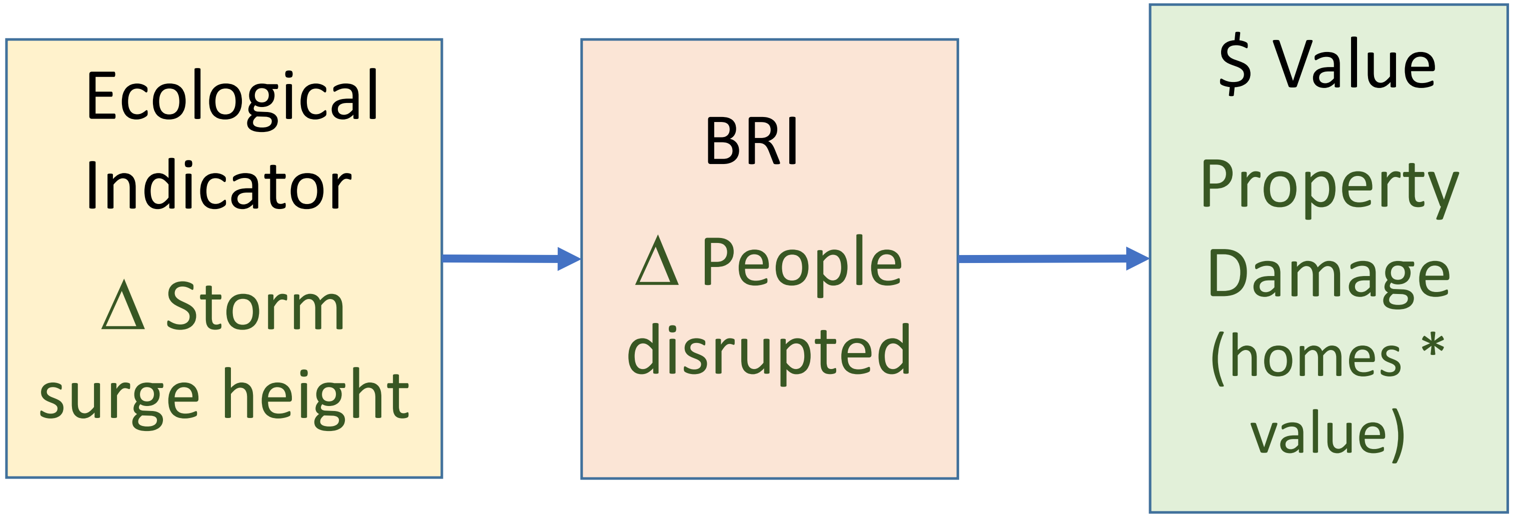
Example of a complement to valuation

Identify equity concerns

Complement

Stepping Stone

Alternative

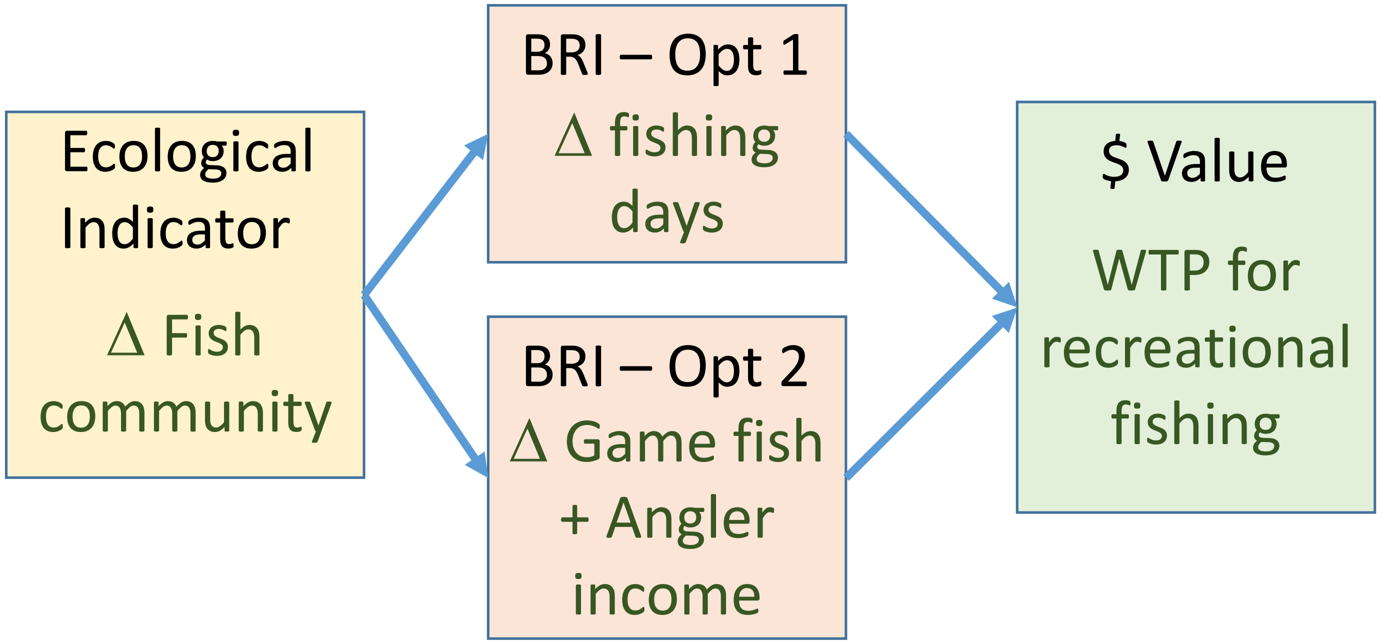


Example of a stepping stone to valuation
Match to benefit transfer variable

Complement

Stepping Stone

Alternative



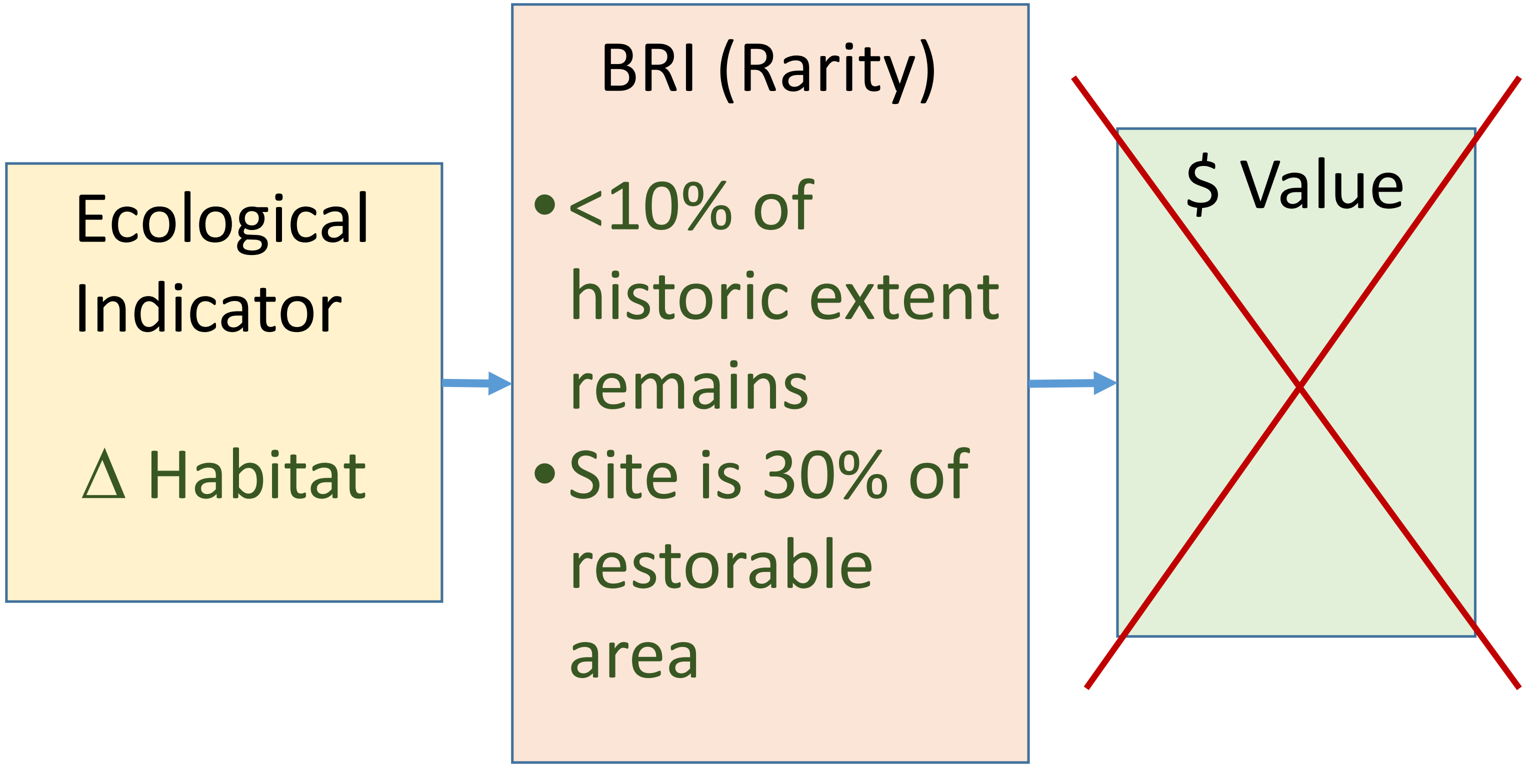
Example of a replacement for valuation

Express relative importance of something that will not be monetized

Complement

Stepping Stone

Alternative



What elements make a good BRI?

- Metrics come as close as possible to something that people would be willing to pay for
- Represents magnitude of use or intensity of concern
- Reveals meaningful tradeoffs

Elements of BRIs

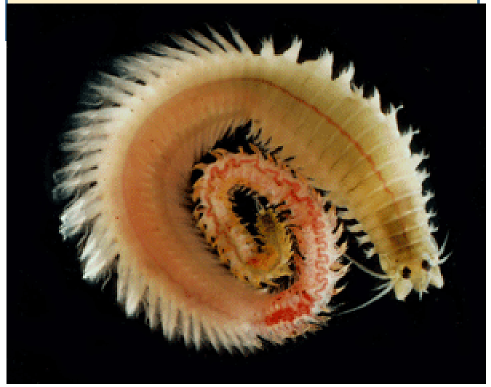
1. Quality is sufficient for users
   - Charismatic birds are present
2. Complements - Capital and labor available
   - Piers and boardwalks provide access
3. Demand - Users or beneficiaries present / possible
   - Potential birders living in driving distance
4. Reliability of the future stream of services
   - Surrounding landscape is protected from development
5. Scarcity and substitutability
   - Few alternative birding sites or other sites are congested

Examples + data realities

Use of site quality

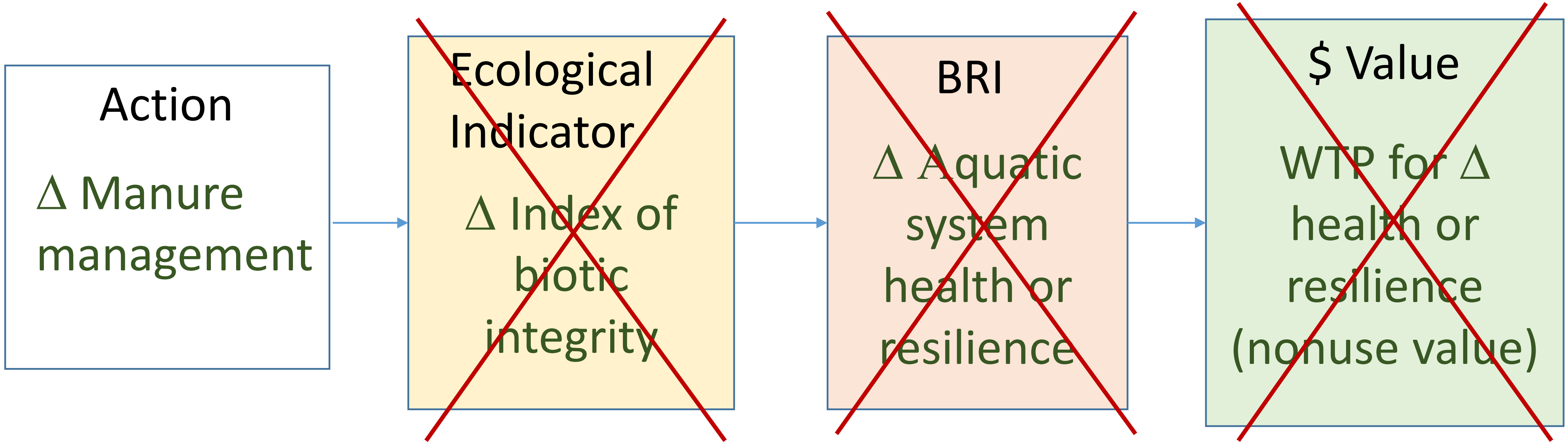
Action	Ecological Indicator	BRI	$ Value
Δ Manure management	Δ Index of biotic integrity	Δ Aquatic system health or resilience	WTP for Δ health or resilience (nonuse value)

Action → Ecological Indicator → BRI → $ Value



Examples + data realities

Use of site quality



Examples + data realities

Use of site quality

Action

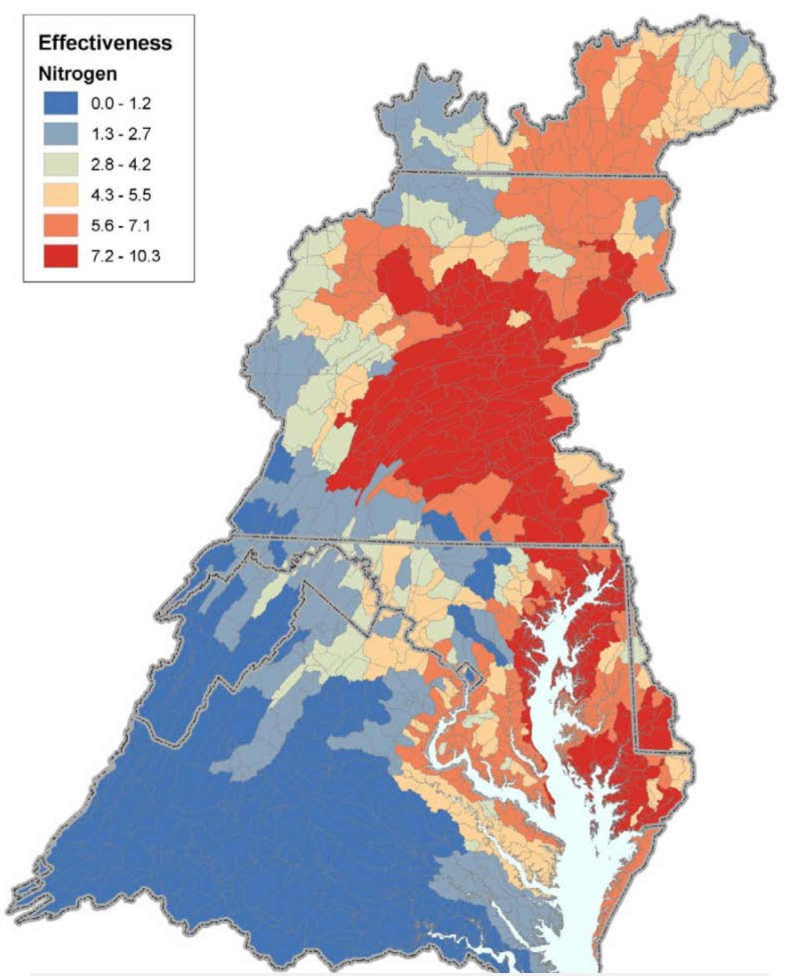
Δ Manure management

~~**Ecological Indicator**~~

~~Δ Index of biotic integrity~~

BRI

Δ Nutrient runoff weighted by effect on aquatic invertebrates



US EPA Chesapeake Bay Program

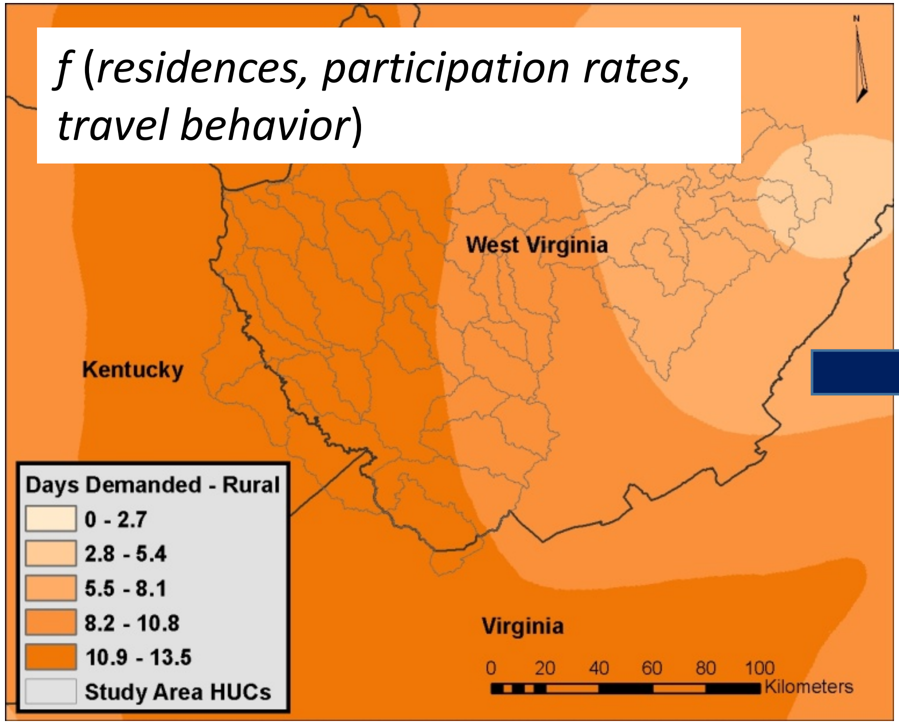
Benefit Relevant Indicator
Complementary Inputs
Co-location of labor and capital

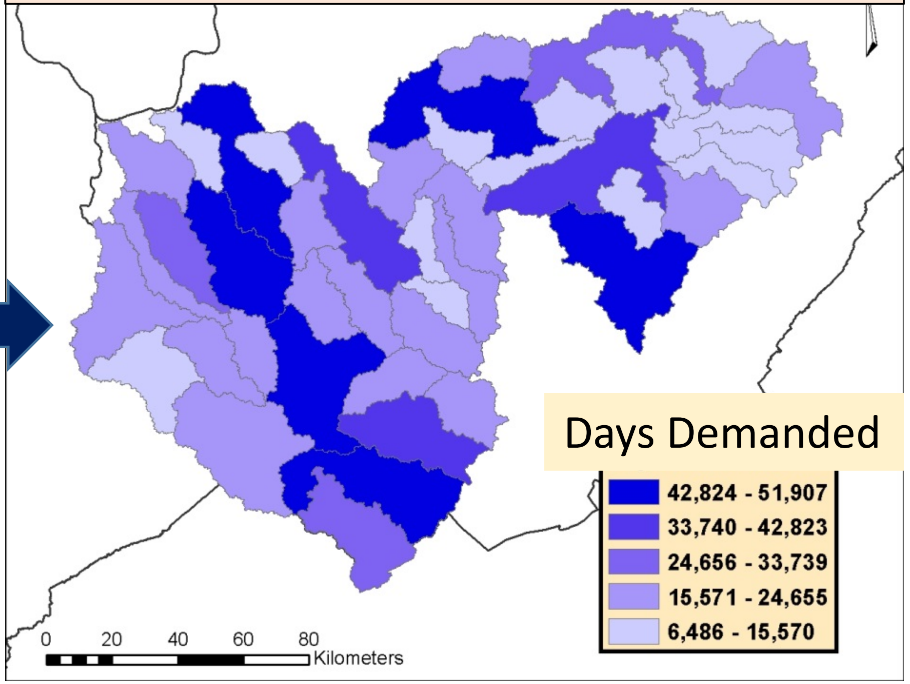
Food Provision
BRI: Area of pollinator-dependent crops within flying distance of pollinator habitat

Benefit Relevant Indicator
Demand

Recreational Fishing

BRI: Increased game fish density in areas of high freshwater fishing demand





Mazzotta, Wainger et al. 2015 *Ecological Economics*

Benefit Relevant Indicator
Scarcity (use value)

Action

∆ Restore streams

→

Ecological Indicator

∆ Groundwater recharge

→

BRI_1

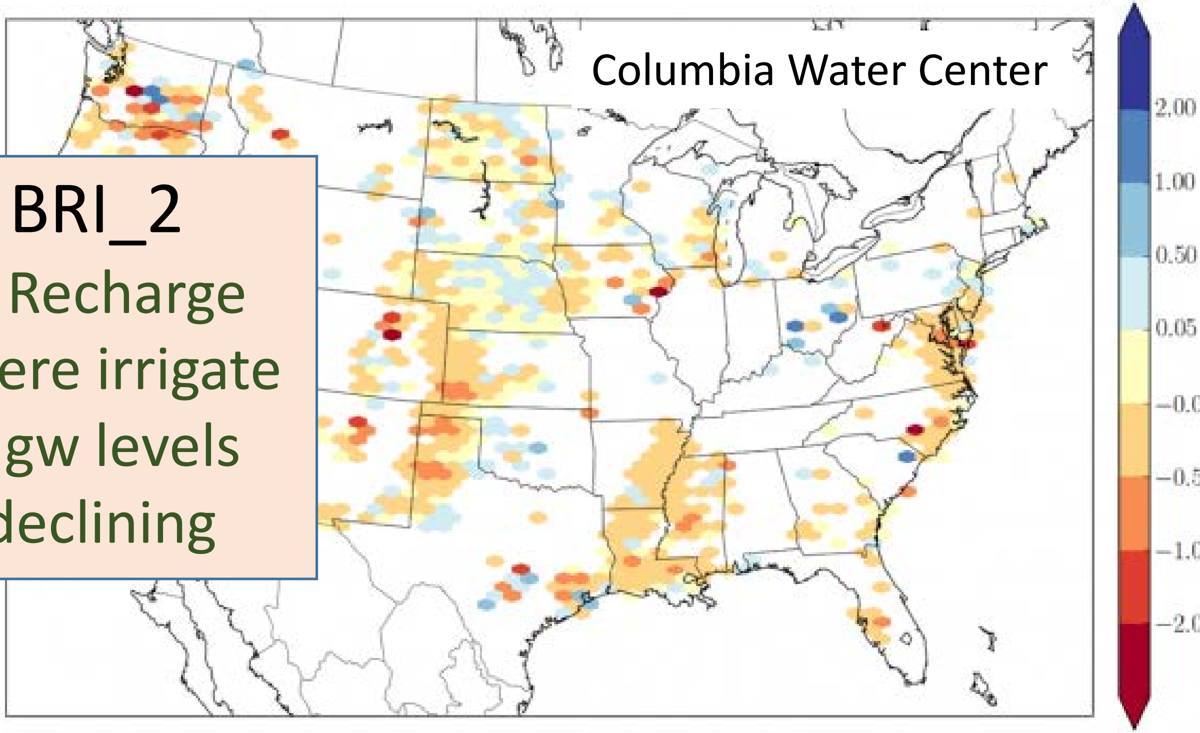
∆ Recharge where irrigation used

→

BRI_2

∆ Recharge where irrigate + gw levels declining

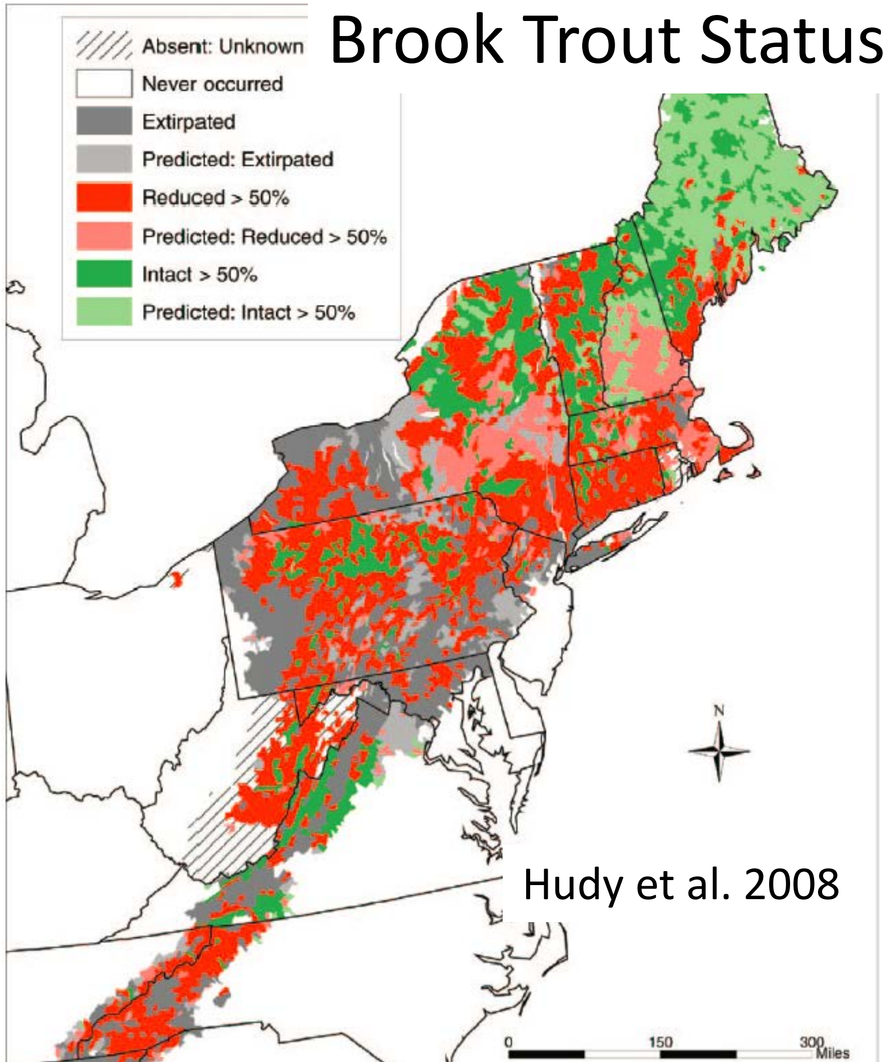
Groundwater Level Trend



Benefit Relevant Indicator

Scarcity (Non-Use)

Brook Trout Status



Hudy et al. 2008

Non-use Value for Species of Concern

BRI: Δ stream miles suitable for reproduction of trout species of conservation concern

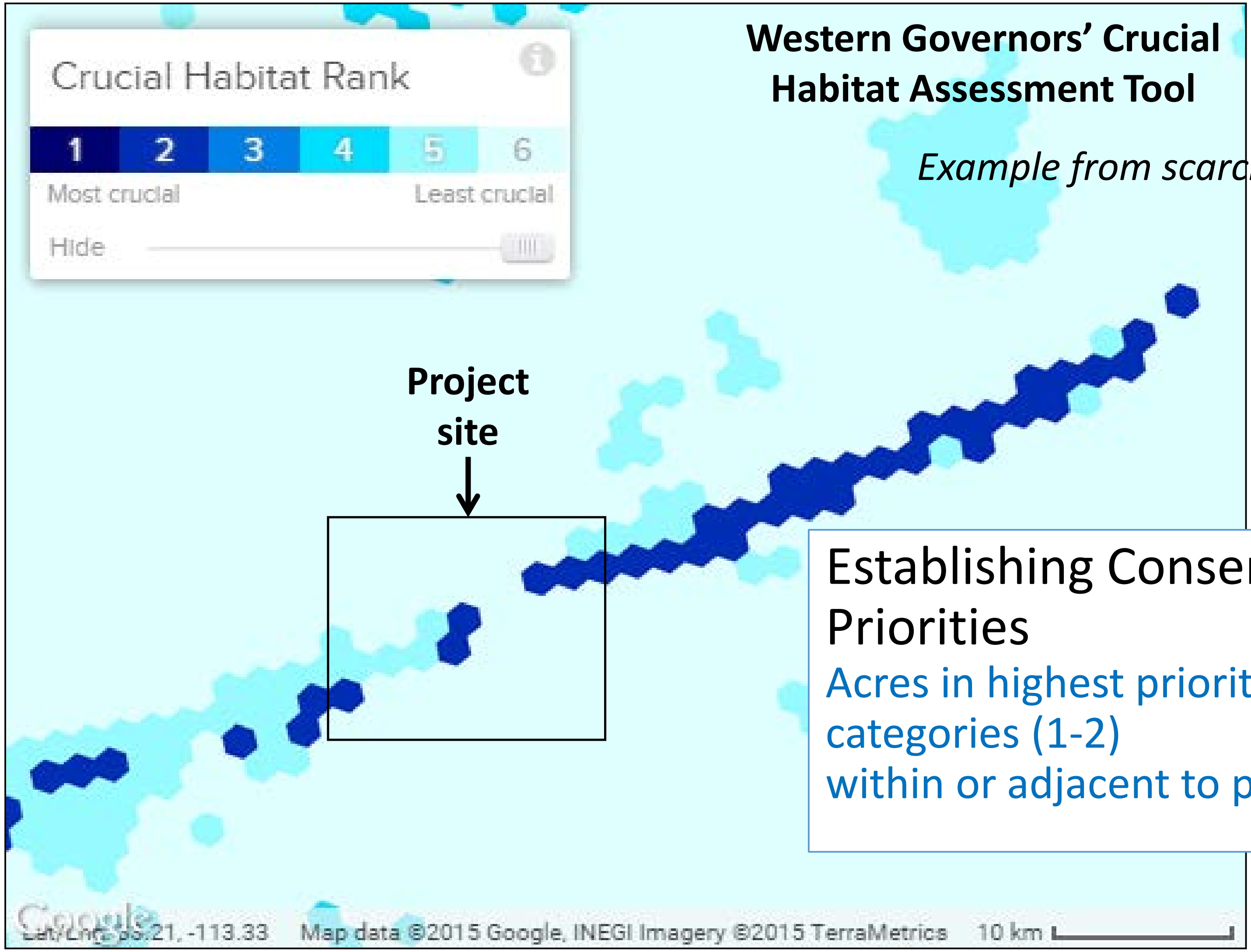
Δ Riparian buffers → Δ Sediment runoff + water temp → Δ Habitat quality for reproduction

The current vs future information gap

Future benefits inferred from existing conditions

Western Governors' Crucial Habitat Assessment Tool

Example from scarcity indicators



Establishing Conservation Priorities

Acres in highest priority categories (1-2) within or adjacent to project

Underpinnings of BRIs

- Scarcity, Substitutability, Irreplaceability

Underlies metric choices

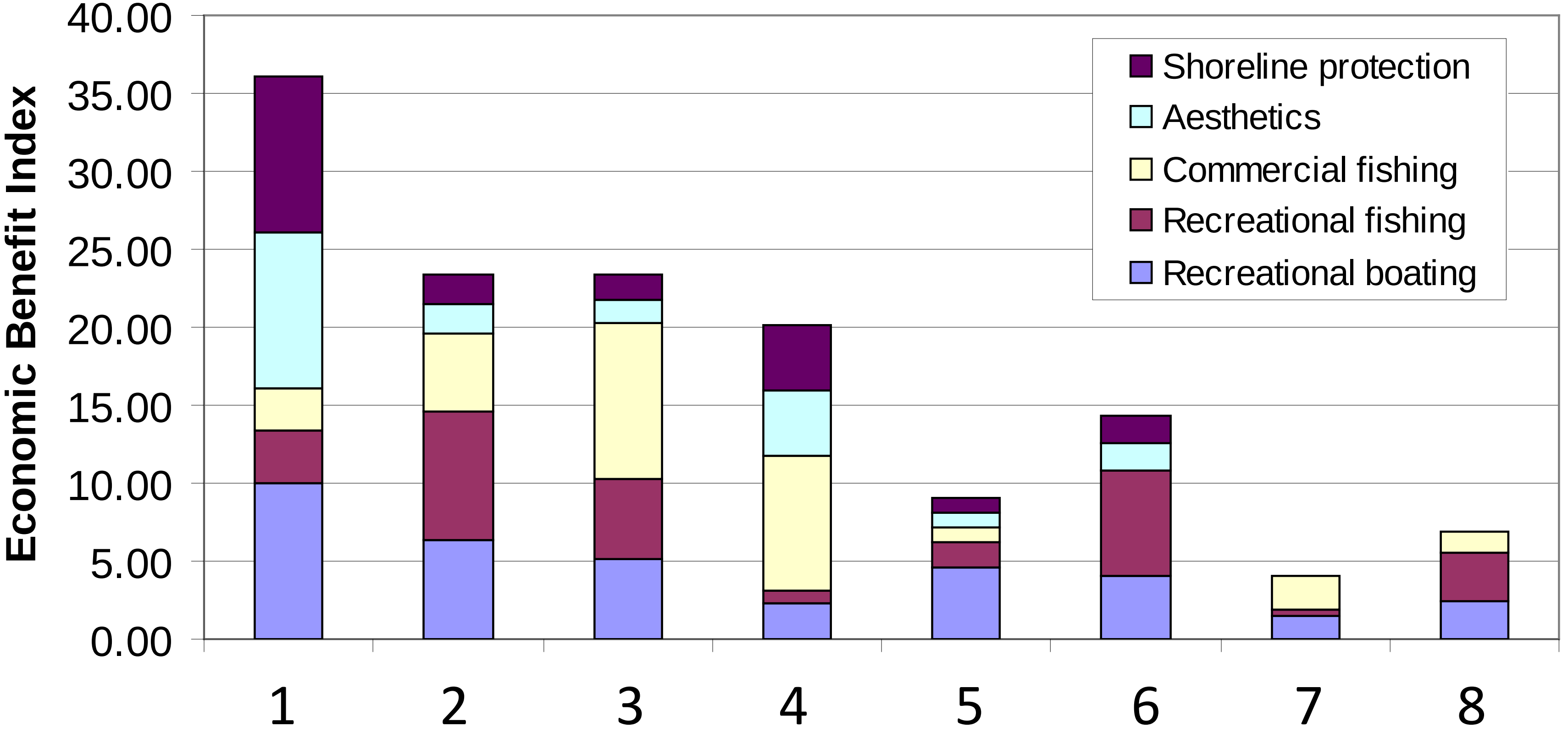
In general, the scarcer a service is, the more an increase in its quantity is likely to be valued, all else equal

- Manage data gaps

Express importance to people to the extent supported by data and understanding

Aggregating Indicators

Do they capture relative importance of changes?



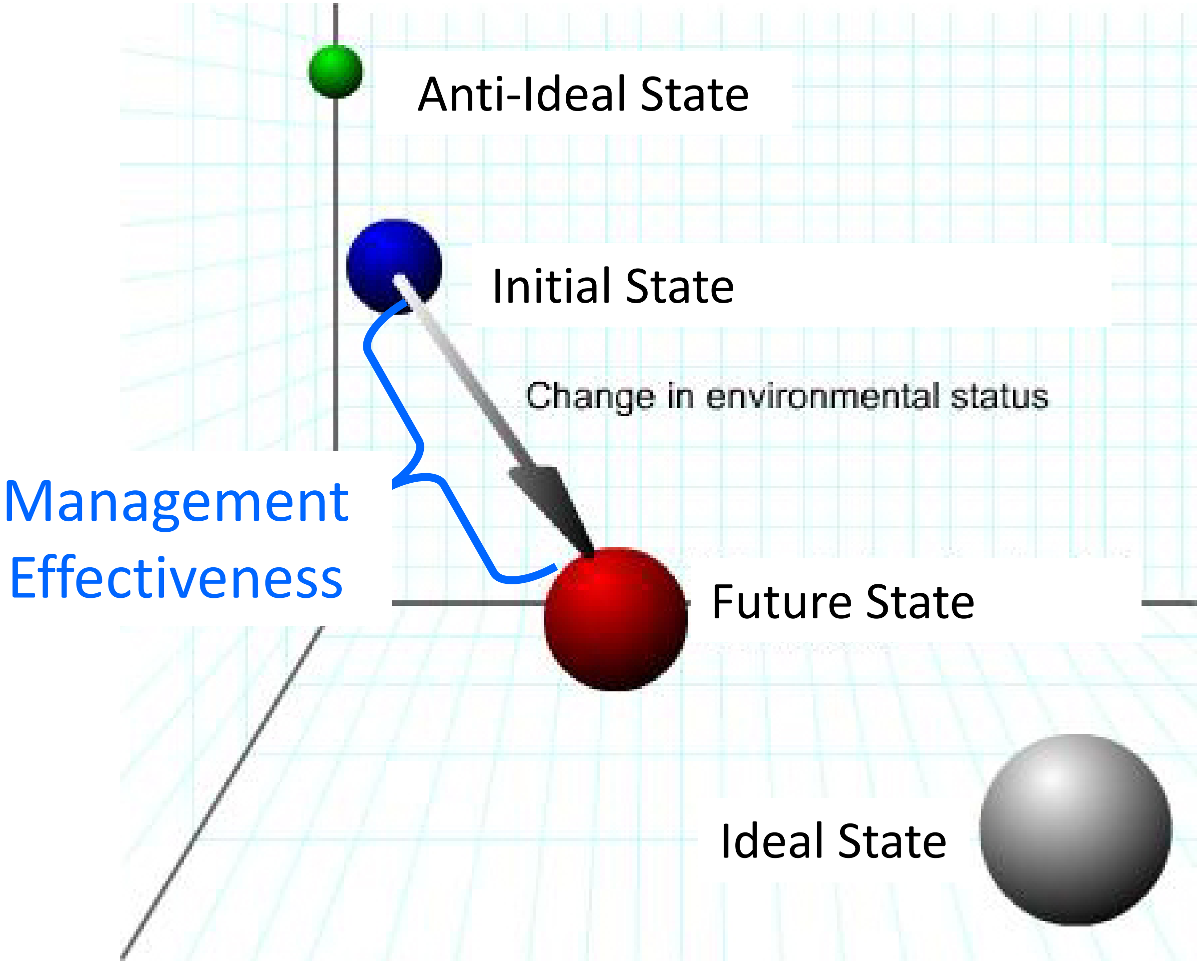
Aggregating indicators
Outside of MCDA

- Use expert judgment and/or statistical properties of data to compare and/or combine variables
- Fill gaps when empirical relationships between variables and outcomes are unknown
- Must be used cautiously to avoid creating bias or unintended consequences

Common aggregation approaches

- Normalization
- Standardization
- Simple weighting
  (user or expert judgement rates intensity of concern)
- Multivariate statistical approaches
  (e.g., evaluate “distance” to a user-specified ideal)

Multivariate distance metrics



Pros and cons of multi-metric aggregation

Pros

- Simplifies results
- Reveals synergies and tradeoffs
- Some methods reduce double counting and/or biases (but not eliminate)

Cons

- Methods embed many unexplored assumptions
  - Often ignore thresholds or other non-linearities in benefits
- Some methods double-count benefits
  = opportunity to game stakeholder processes
- Simple mathematical choices can unintentionally bias results
  - E.g., A single high or low outlier values can make moderate changes appear unimportant when normalizing

Source of further information

Locantore et al. 2009

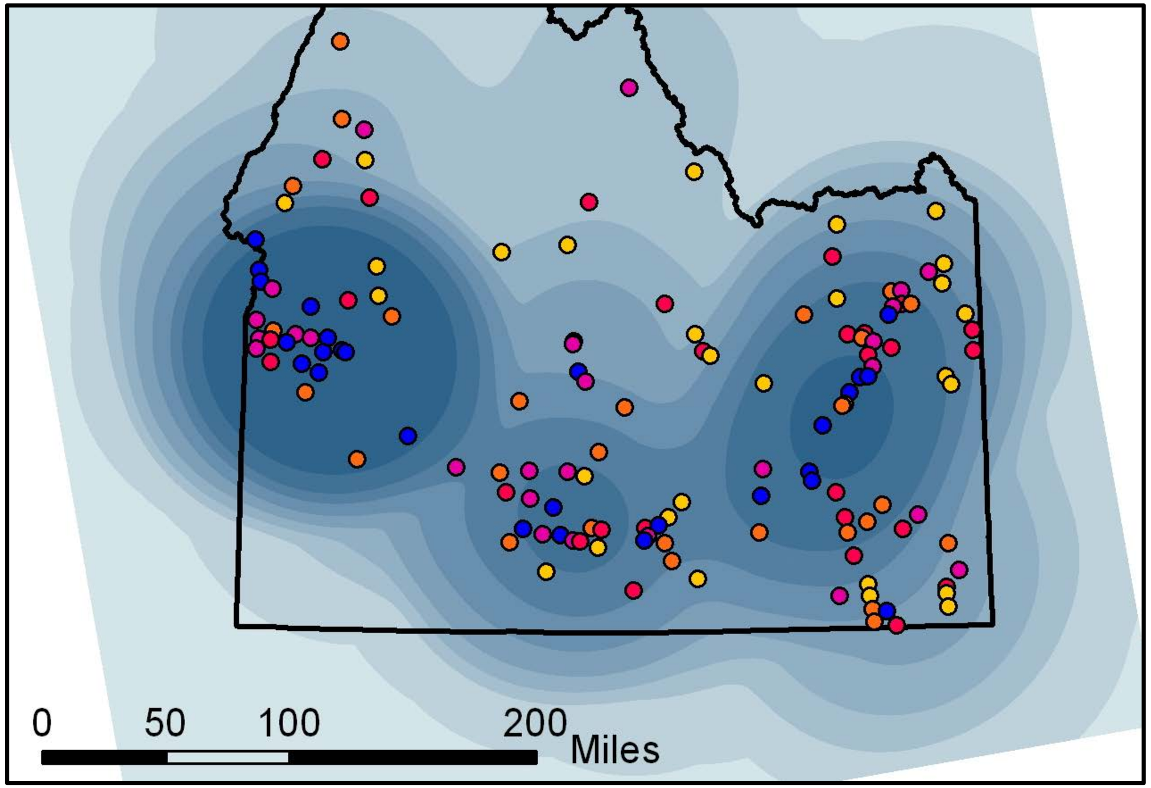
EPA Regional Vulnerability Assessment Program

Category	Method	Description	Reference
Basic	Best/Worst Quintile	Count the number of variables in the best/worst quintile.	Jones et al., 1997
	Sum	Add the normalized values of all variables.	
Distance-based	PCA Distance	Transform variables to adjust for correlations, then calculate Euclidean distance from a reference.	
	State Space	Adjusts for correlations by calculating the Mahalanobis distance from a reference.	Johnson, 1988; Mahalanobis, 1936
	Criticality	Calculates fuzzy distance to a hypothetical "natural" state.	Dubois, 1979; Gatto and Renaldi, 1987; Tran and Duckstein, 2002
	Analytical Hierarchy Process (AHP)	Multi-criteria tool that uses decision-maker preferences in the calculations.	Saaty, 1980
Grouping	Cluster Analysis	Uses a robust partitioning method to group watersheds.	Wickham et al., 1999
	Self-organizing Maps (SOM)	Uses neural networks to group watersheds.	Kohonen, 2001; Tran et al., 2003
Overlay	Stressor-Resource Overlay	Composite coloring, counts high-stress variable values and high-resource variable values.	Landis and Wiegers, 1997; Jackson et al., 2004
	Overlap	Comparison of two regional maps to highlight differences.	
Matrix	Stressor-Resource Matrix	Computes scores based on correlation values to rate stressors and resources.	Gentile, et al., 1999; Harris et al., 1994; Parkhurst et al., 1997
	Univariate Regression	Computes scores based on regressions of stressors on individual resources.	

Other Analytic Details

Spatial extent considerations (servicesheds)

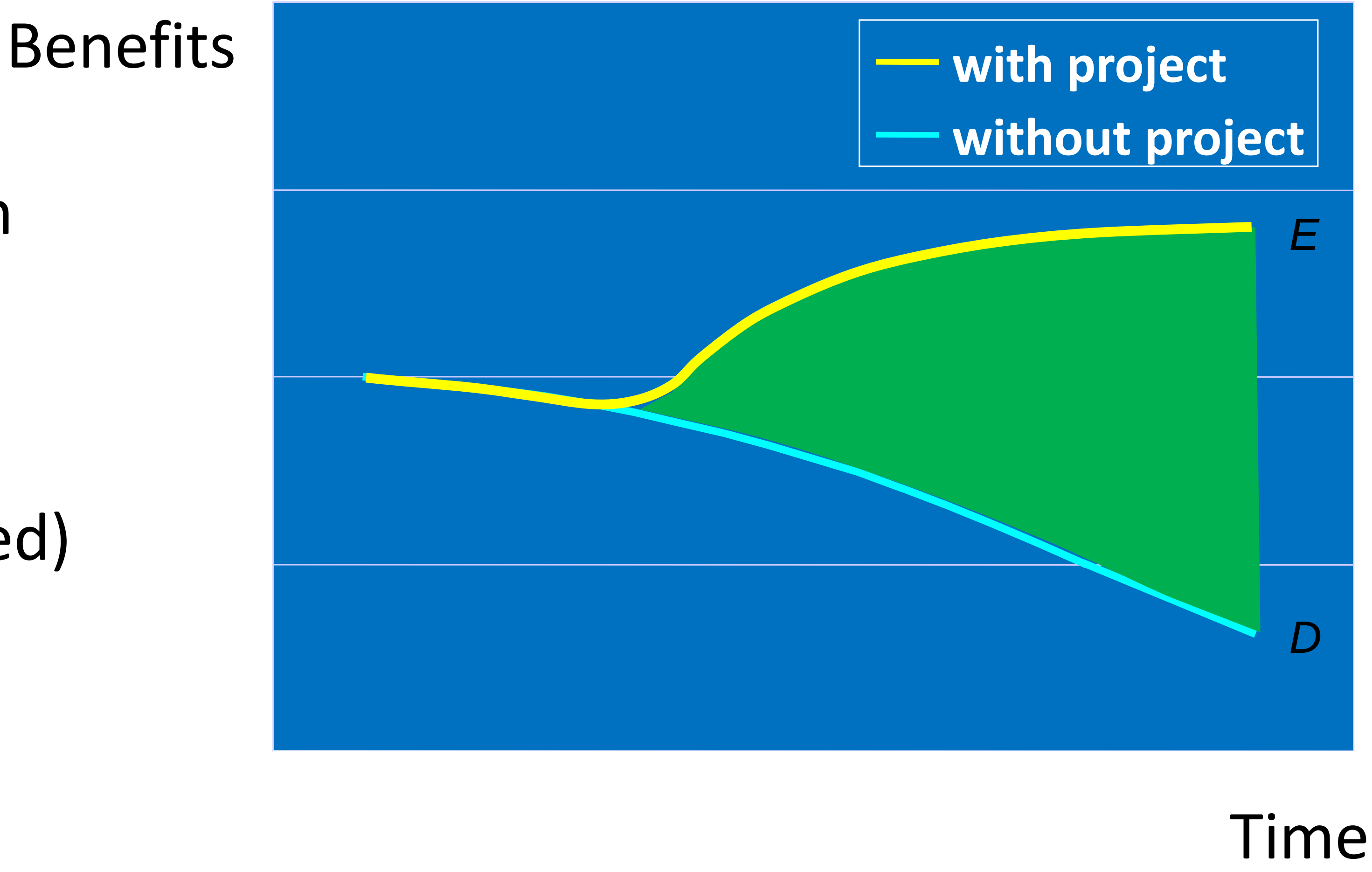
- Does service value decline with distance?
- What is the appropriate range of beneficiaries?
    - Species ranges (e.g., pollinators)
    - Networks & social conditions (e.g., downstream, likely driving distance)
    - Proximity-independent (e.g., climate risk mitigation)



Other Analytic Details

Temporal Analysis Issues

- Benefits are often measured as a stream of services through time
- Benefits may depend on future (unmeasured) conditions
- Not obvious how to discount future BRIs



BRIs fulfill two important needs for ecosystem services assessments

1. Enable lay audiences to clearly connect ecological outcomes to their own well-being
2. Improve analysis of tradeoffs by representing benefits that are not possible or feasible to monetize

Resources

Descriptions of Methods

- NESP guidebook; Quantifying BRIs: https://nespguidebook.com/assessment-framework/quantifying-social-and-economic-context-in-bris/
- Wainger LA, Boyd JW. 2009. Valuing ecosystem services. Pages 92–111 in K. McLeod and H. Leslie, editors. Ecosystem-Based Management for the Oceans. Island Press, Washington, DC.
- Wainger et al. (in press). A proposed ecosystem services analysis framework for the US Army Corps of Engineers. ERDC/EL TR-xx-xxx. Vicksburg, MS: U.S. Army Engineer Research and Development Center

Some example implementations of BRIs

- Mazzotta, M.J., Bousquin, C. Ojo, K. Hychka, C. Druschke, W. Berry, and Rick Mckinney. 2016. Assessing the Benefits of Wetland Restoration: A Rapid Benefit Indicators Approach for Decision Makers. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-16/084.
- Wainger LA, King DM, Mack RN, Price EW, Maslin T. 2010. Can the concept of ecosystem services be practically applied to improve natural resource management decisions? Ecological Economics 69:978–987.
- Boyd J, Wainger LA. 2002. Landscape Indicators of Ecosystem Service Benefits. American Journal of Agricultural Economics 84:1371–1378.
- Wainger LA, King DM, Salzman J, Boyd J. 2001. Wetland value indicators for scoring mitigation trades. Stanford Environmental Law Journal 20:413–478.

Technical resources

- *Metric Aggregation:* Locantore, N., L. T. Tran, R. V. O'Neill, P. W. Mickinnis, E. R. Smith, M. O'Connell. 2004. An overview of data integration methods for regional assessment. Environmental Monitoring and Assessment. 94. 249-261.
- *Demand Assessment:* Mazzotta M, Wainger L, Sifleet S, Petty JT, Rashleigh B. 2015. Benefit transfer with limited data: An application to recreational fishing losses from surface mining. Ecological Economics 119:384–398.
- *Scarcity data sources and metric aggregation:* Wainger, L., K. Gazenski, E. Murray. (in review). Using scarcity and reliability data to value ecosystem services: assessment of currently available resources and metric aggregation methods. USACE ERDC Technical Report; some info at waingerlab.cbl.umces.edu/ecoscarcity (and Gazenski et al. **poster at ACES 2016**)

Developing Benefit Relevant Indicators

EXERCISE

BRI Exercise Steps

1. Select a conceptual model
2. Develop BRIs that incorporate at least one of these elements
    - Quality is sufficient
    - Complements - Capital and labor co-located / available
    - Demand - Users or beneficiaries present / possible
    - Reliability of the future stream of services
    - Scarcity and substitutability
3. Produce flow chart summarizing BRIs and connections

<u>Factors to consider</u>

- Qualities relevant to beneficiaries
- Complements - Capital and labor
- Demand - Users or beneficiaries
- Reliability
- Scarcity and substitutability

<u>BRIs (people implicit)</u>

Weight extent of biophysical change by a quality that is relevant to beneficiaries

Examples:

- Area with stable groundwater levels (water supply)
- Number of rare species with enhanced population viability (non-use value of aquatic ecosystem)

<u>BRIs (people explicit)</u>

Weight a biophysical change by the number of affected people or the intensity of concern

Examples:

- Number of private well users with stable groundwater supply