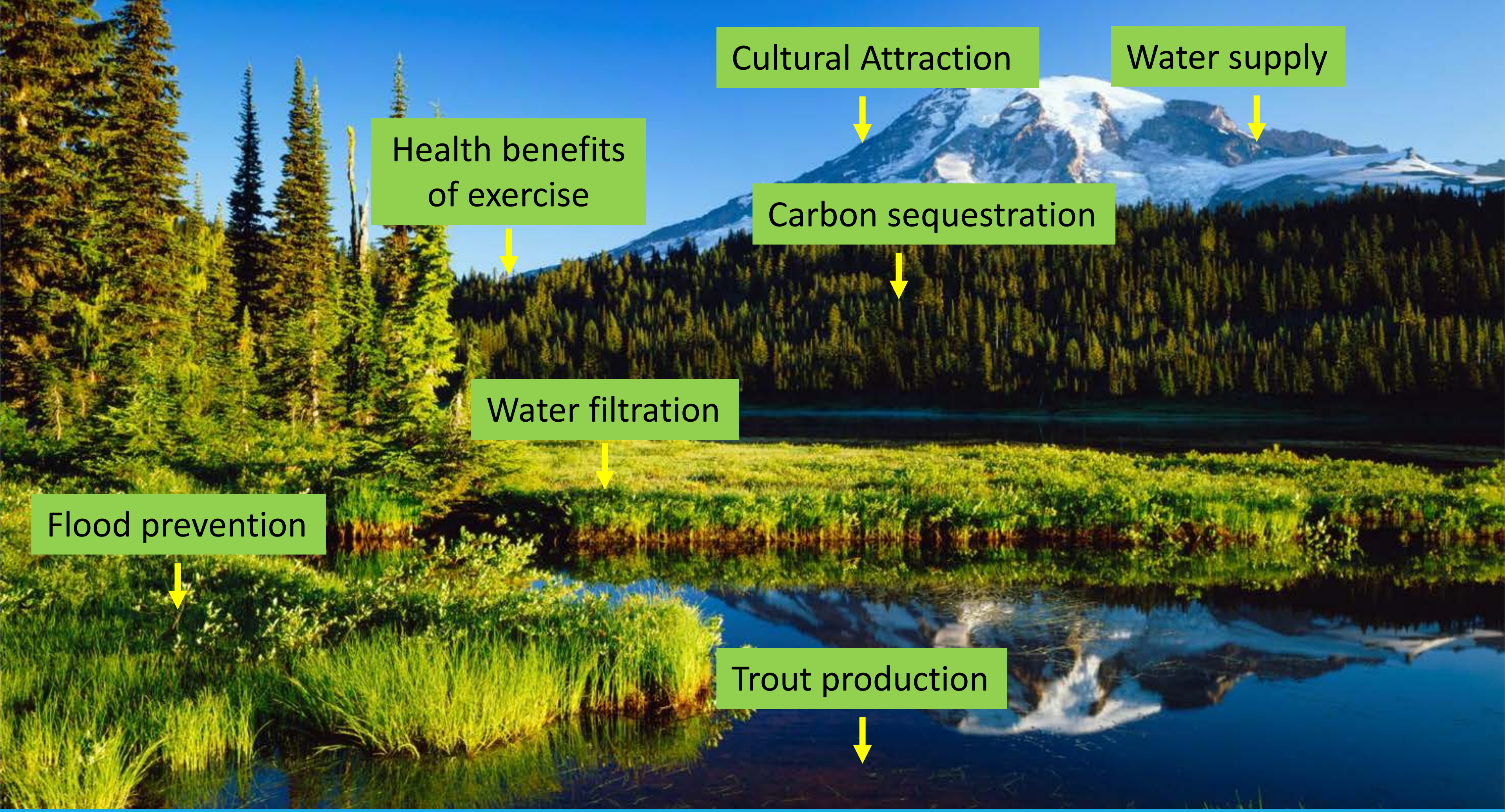


Benefits Assessment – Valuation methods

National Ecosystem Services Partnership

Ecosystem Service Values

- Ecosystem services may be defined as the aspects, flows or conditions of natural systems that benefit society.
  - “the flows from an ecosystem that are of relatively immediate benefit to humans and occur naturally” (Brown et al. 2007).
- The goal is a formal link between changes in ecosystems and changes in human well-being.
- Ecosystem service values are not limited to market values. Money does not have to be exchanged for a value to exist. Many services provide non-market values.
  - Values for things that are not directly bought and sold in markets, e.g., changes in recreational fishing, clean air and water, pollination, natural flood control.

Ecosystem Service Values

- Economic values provide a consistent means to quantify and compare changes to ecosystem services, in terms of their value to people.
- Economic values quantify changes in well-being in consistent and directly comparable units.
- Although the methods of measuring values can differ, the theory underlying value estimation is the same as that applied to market goods. The same rules apply.

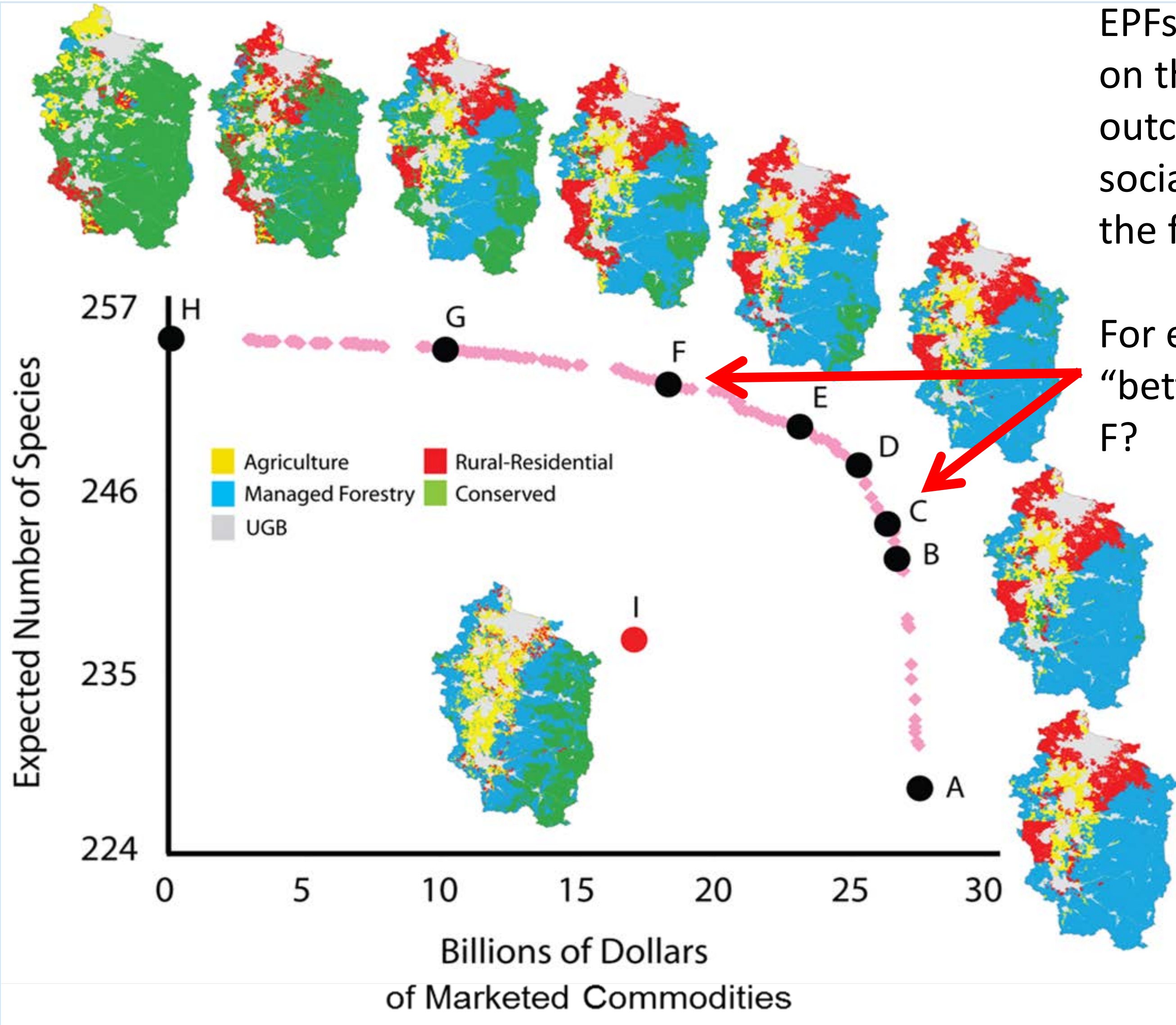
Why is Economic Valuation Useful?

- Economic valuation (like all valuation) is reductionist—it conveys value using a set of monetary metrics.
- It is designed to be one of the tools used to inform decisions, not the only tool.
- Unlike other ways of characterizing value, *correctly estimated* economic values are:
  - Quantified in units with clear meaning (e.g., dollars)
  - Of consistent interpretation across projects and methods.
  - Comparable to project costs quantified in monetary units.
  - Directly comparable across individuals, regions, services, etc.

When is Economic Value Required?

- BRIs measure *what is valued*, but do not measure *values*. When is valuation (or preference evaluation) required?
- Preference evaluation (including monetary or non-monetary valuation) is informative whenever *tradeoffs must be evaluated*. Examples include when:
  - Service provision varies substantially across different human populations, i.e., there are *tradeoffs across groups*; or
  - Ecosystem service changes vary in direction or magnitude across services, i.e., there are *tradeoffs across services*.
  - The *costs of actions that affect ecosystem services must be compared to the benefits* of these actions.
  - More is not monotonically better (e.g., deer populations).

Tradeoffs and Values



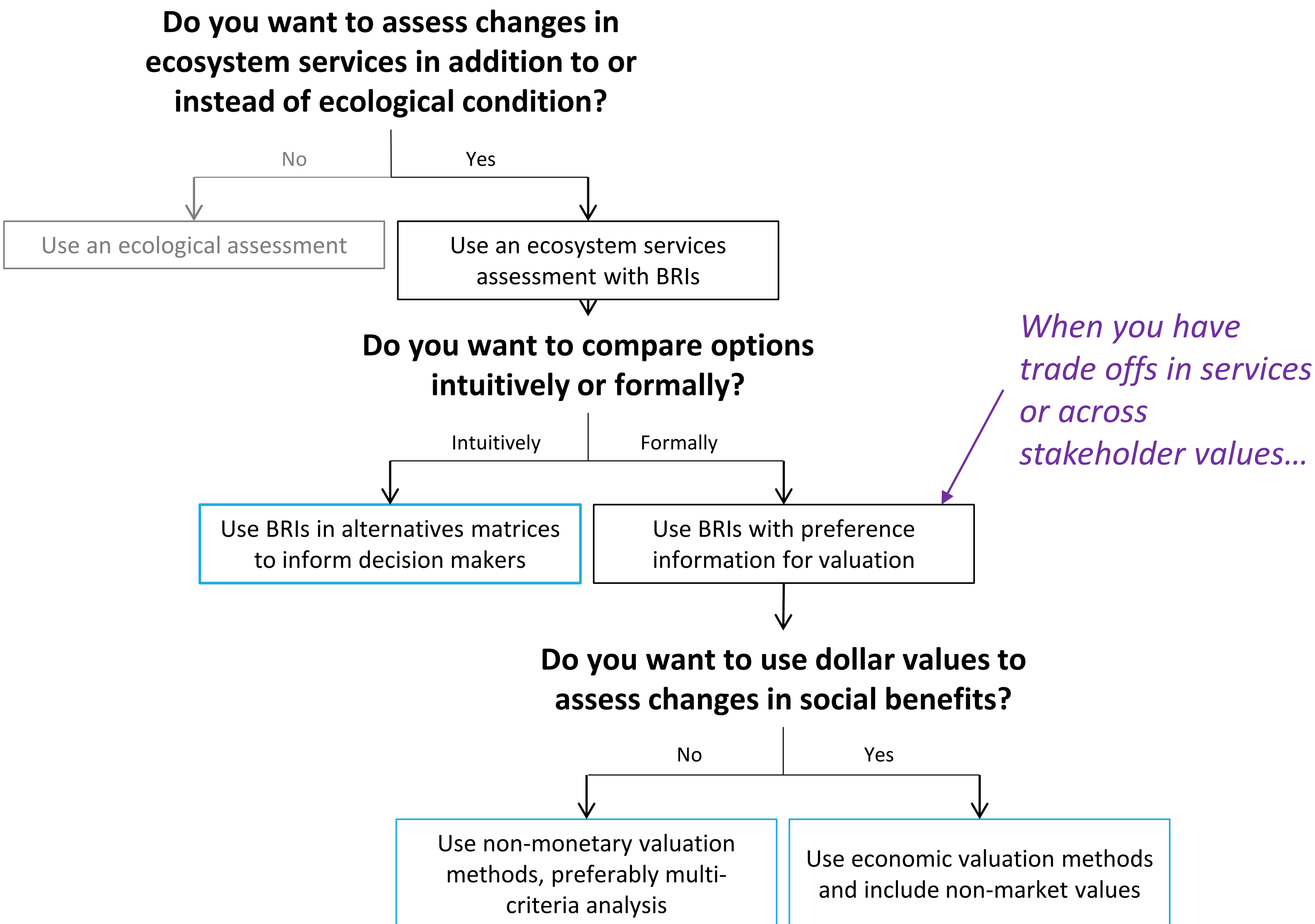
EPFs provide information on the frontier of possible outcomes, but not on the socially optimal point on the frontier.

For example, which is "better," point C or point F?

The answer depends on relative social value.

Source: S. Polasky, et al. "Where to Put Things? Spatial Land Management to Sustain Biodiversity and Economic Returns," Biological Conservation 141(6) (2008):1505–1524

Decision Tree for Methods



Types of Preference Evaluation

- There are two main quantitative approaches to preference evaluation
  - Monetary (or economic) valuation
  - Non-monetary multi-criteria analytical methods
- This presentation focuses on *economic valuation*
  - Commonly applied and often required by government agencies (due to executive orders or statutes)
  - Directly comparable across sites and projects
  - May be used for benefit transfer

Key Concepts of Economic Value

- For something to have value (and hence be an ecosystem service or BRI), it must be valued either directly or indirectly by humans, because it enhances quality of life.
- Example: Existence values (nonuse) are a type of economic value. “Intrinsic” values are not.
- Values are measured (implicitly or explicitly) in terms of *tradeoffs*— what is the maximum one would be willing to give up in terms of
  - other goods/services (I’ll would be willing to give up my sandwich for a chocolate bar)
  - time (it takes an extra hour for me to travel to a better fishing site, but it’s worth it to me)
  - money (I’m willing to pay $50 a night more for the room with the ocean view)

Key Concepts of Economic Value

- Economic values are measured in terms of a marginal quantity of a good or service, from a known baseline.
  - NO: The total value of Narragansett Bay is $X.
  - YES: The value of a 5% increase in clam harvest in Narragansett Bay, from the current level, would be $Y.
- Example—it is possible, in principle, to estimate the economic value of additional fish "produced" by an additional X acres of coastal wetland in a specific area.
- It is *not* possible to estimate the economic value of all wetlands in the world, or the value of Long Island Sound.
  - These are not meaningful economic values.

Precursors to Economic Valuation

- Economic valuation requires:
  - A well-defined set of ecosystem services, generally measured as BRIs (what services generate the value?)
  - A well-defined baseline and set of changes (what are the ecosystem service changes to be valued?)
  - A well-defined set of beneficiaries in a specific set of areas (who receives the value?)
  - A well-defined set of values to be estimated (what type of values are to be measured?)
  - The use of valid and credible valuation methods (how are these values to be measured?)
- The first three of these requirements have already been discussed. Here we focus on the remaining two issues.

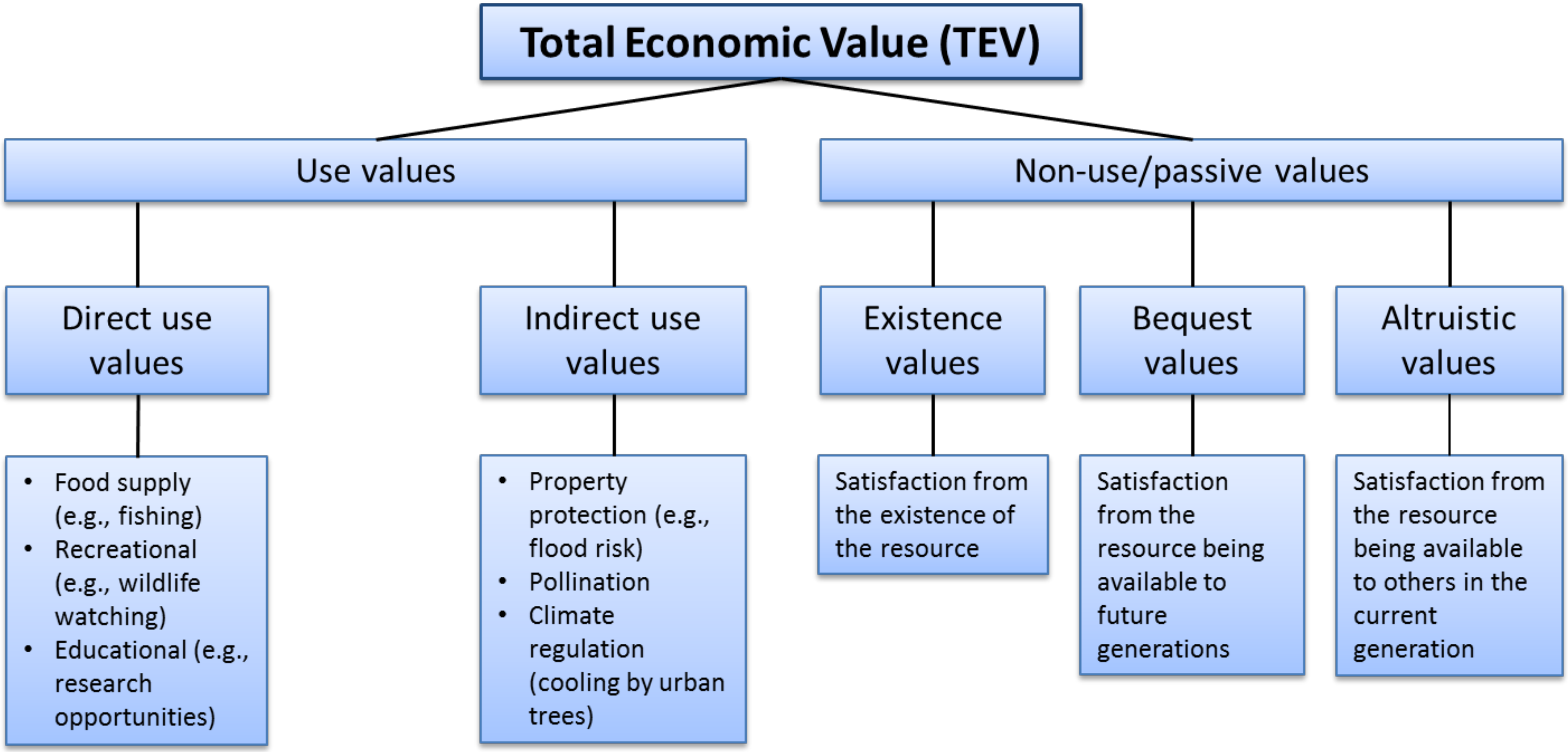
Beneficiaries

- Measures of ecosystem services depend on whose values are to be measured—the beneficiaries.
- One cannot define ecosystem services until one defines the relevant beneficiary groups. *If you have not defined the beneficiaries you are not doing ecosystem service valuation*.
- Changes in ecosystem features and functions often involve different benefits realized by multiple groups.
- It is often infeasible to measure all possible benefits to all possible groups. Choices must be made regarding the primary benefits to be measured, and to whom.
- “Whose values count” depends on a variety of factors, including legal/statutory restrictions and goals of the analysis.

How Economists Define Value

- Economists measure economic value in terms of willingness to pay (WTP), or sometimes willingness to accept (WTA).
- WTP is a theoretical concept that gives meaning to the monetary measure:
  - Defined as the maximum amount of money or some other good a person or group would be willing to give up in exchange for a good or service, rather than go without.
- When you measure economic value you are measuring (or approximating) WTP or WTA, whether you recognize it or not.
- Whether WTP or WTA is appropriate depends on various factors, including assumed property rights.
- WTP does not necessarily imply contingent valuation!

Different Types of Economic Value



Note: Source: NESP guidebook. Adapted from R.K.K. Turner, S.G. Georgiou, and B. Fisher, *Valuing Ecosystem Services: The Case of Multi-Functional Wetlands* (London: Earthscan, 2008).

Methods for Measuring Value

- Once the BRIs, beneficiaries and values (to be measured) are identified, one can determine the methods best suited to measuring these values.
- Different methods are applicable depending on whether these are market or non-market values.
- Methods for market valuation are often straightforward, based on analysis of market prices and quantities.
- Many ecosystem services generate large non-market values.
- Non-market valuation can be more challenging and require greater expertise.

Valuation Methods (Primary Study)

Table 1. Primary valuation methods applied to ecosystem services.

	Valuation Method	Description	Examples of Ecosystem Services Valued
Market Valuation[a]	Market Analysis and Transactions	Derives value from household's or firm's inverse demand function based on observations of use	Fish, Timber, Water, Other raw goods
	Production Function	Derives value based on the contribution of an ecosystem to the production of marketed goods	Crop production (contributions from pollination, natural pest control). Fish production (contributions from wetlands, seagrass, coral)
Revealed Preference	Hedonic Price Method	Derives an implicit value for an ecosystem services from market prices of related goods	Aesthetics (from air and water quality, natural lands). Health benefits (from air quality)
	Recreation Demand Methods	Derives an implicit value of an on-site activity based on observed recreational travel behavior	Recreation value (contributions from: Water quality and quantity Fish and bird communities. Landscape configuration Air quality)

Source: NESPguidebook.com. Originally a**dapted from** Table 4.8 in **Turner,** Georgiou, and Fisher **(2008)**.

[a] Some typologies consider market valuation a type of revealed preference analysis.

[b] Most typologies group defensive and damage cost methods under revealed preference techniques.

Table 1. Primary valuation methods applied to ecosystem services.

	Valuation Method	Description	Examples of Ecosystem Services Valued
Revealed Preference: Cost Avoided and Public Pricing[b]	Damage Costs Avoided	Value is inferred from the direct and indirect expenses incurred as a result of damage to the built environment or to people.	Flood protection (costs of rebuilding homes) Health and safety benefits (treatment costs)
	Averting Behavior / Defensive Expenditures	Value is inferred from costs and expenditures incurred in mitigating or avoiding damages	Health and safety benefits (e.g., cost of an installed air filtration system suggests a minimum willingness-to-pay to avoid discomfort or illness from polluted air)
	Replacement / Restoration Cost	Value is inferred from potential expenditures incurred from replacing or restoring an ecosystem services.	Drinking water quality (treatment costs avoided). Fire management
	Public Pricing	Public investment serves as a surrogate for market transactions (e.g., government money spent on purchasing easements).	Non-use values (species and ecosystem protection). Open space. Recreation
Stated Preference	Contingent Valuation (open-ended and discrete choice)	Creates a hypothetical market by asking survey respondents to state their willingness-to-pay or willingness-to-accept payment for an outcome (open-ended), or by asking them whether they would vote for or choose particular actions or policies with given outcomes and costs (discrete choice).	Non-use values (species and ecosystem protection), Recreation. Aesthetics
	Choice Modeling / Experiments	Creates a hypothetical market by asking survey respondents to choose among multi-attribute bundles of goods with associated costs and derives value using statistical models.	Non-use values (species and ecosystem protection). Recreation. Aesthetics

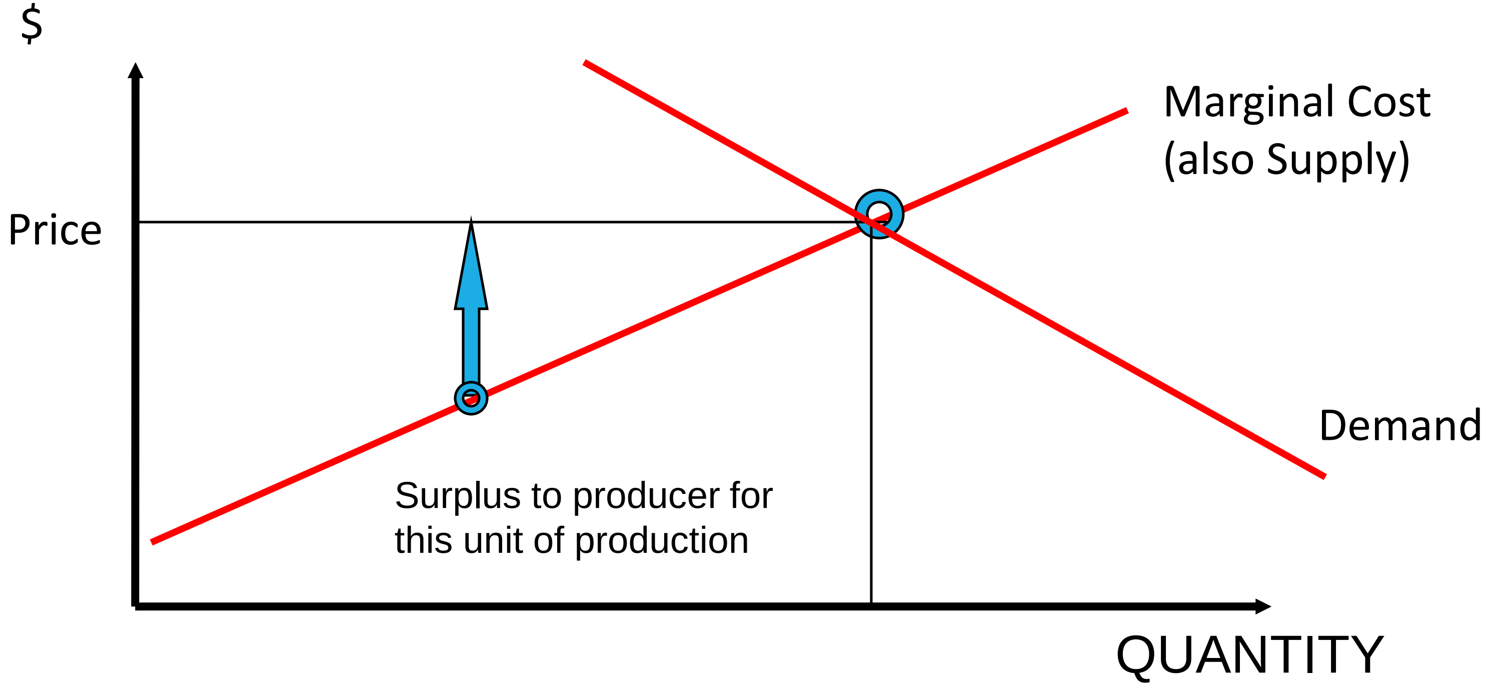
- Cost avoided and public pricing methods generate accurate measures of economic value only *under very narrow and restrictive circumstances (if at all)*.

Primary Valuation Studies

- Note that none of these methods measures jobs or "economic impacts" such as local economic activity.
  - These are not valid measures of economic value.
  - Natural disasters or warfare can generate lots of jobs and income, but do not enhance net social benefit.
  - Simply because something is measured in monetary terms does not mean it qualifies as an economic value.
- All valuation approaches require specialized expertise and data collection for the affected sites—spreadsheet tools are only rarely sufficient.
- Economists should be involved from the beginning of any ecosystem services assessment, to ensure that biophysical measures (BRIs) and EPFs are suitable to inform valuation.

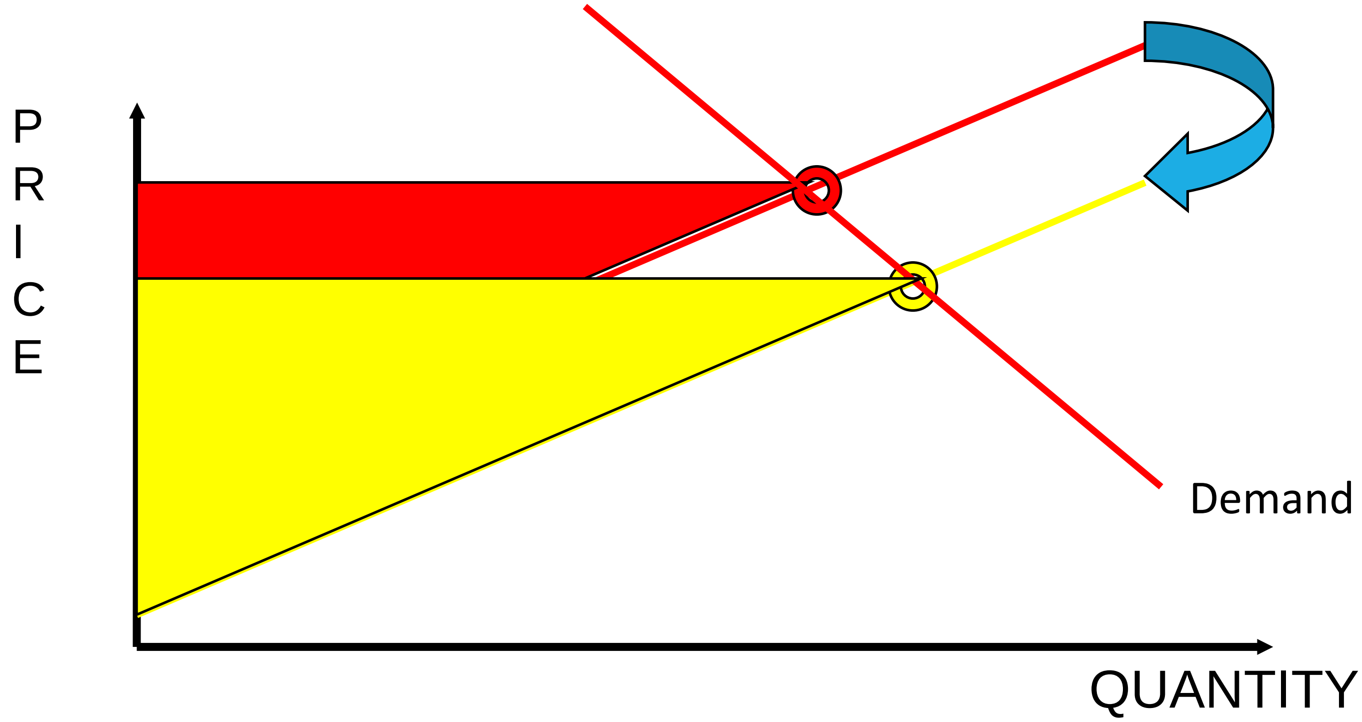
Example—Factor Inputs (Value to Producers)

Consider a market product produced with an ecosystem service as an input (e.g., shrimp). Producer value is the difference between revenue and cost for each unit sold.



Example—Factor Inputs (Value to Producers)

Habitat restoration increases shrimp abundance (EPF) and decreases the marginal cost of harvest (economic modeling). The difference between the red and yellow triangles is the value of the change.



A Simple Spreadsheet Example

- **Degraded Habitat**
  - Catch rate per day = 5,000 lbs.
  - Dockside Price = $0.70
  - Variable cost per pound = $0.50
  - Total days fished in season = 16
  - Total revenue = 16 x 5,000 x $0.70 = $56,000
  - Total variable costs = 16 x 5,000 x $0.50 = $40,000
  - Producer Surplus = $56,000 - $40,000 = $16,000

- **Improved Habitat**
  - Catch rate per day = 8,000 lbs.
  - Dockside Price = $0.70
  - Variable cost per pound = $0.40
  - Total days fished in season = 16
  - Total revenue = 16 x 8,000 x $0.70 = $89,600
  - Total variable costs = 16 x 8,000 x $0.40 = $51,200
  - Producer Surplus = $89,600 - $51,200 = $38,400

Change in Ecosystem Service Value to Shrimp Harvesters = $22,400 / yr.
Additional values may be realized by consumers if prices change.

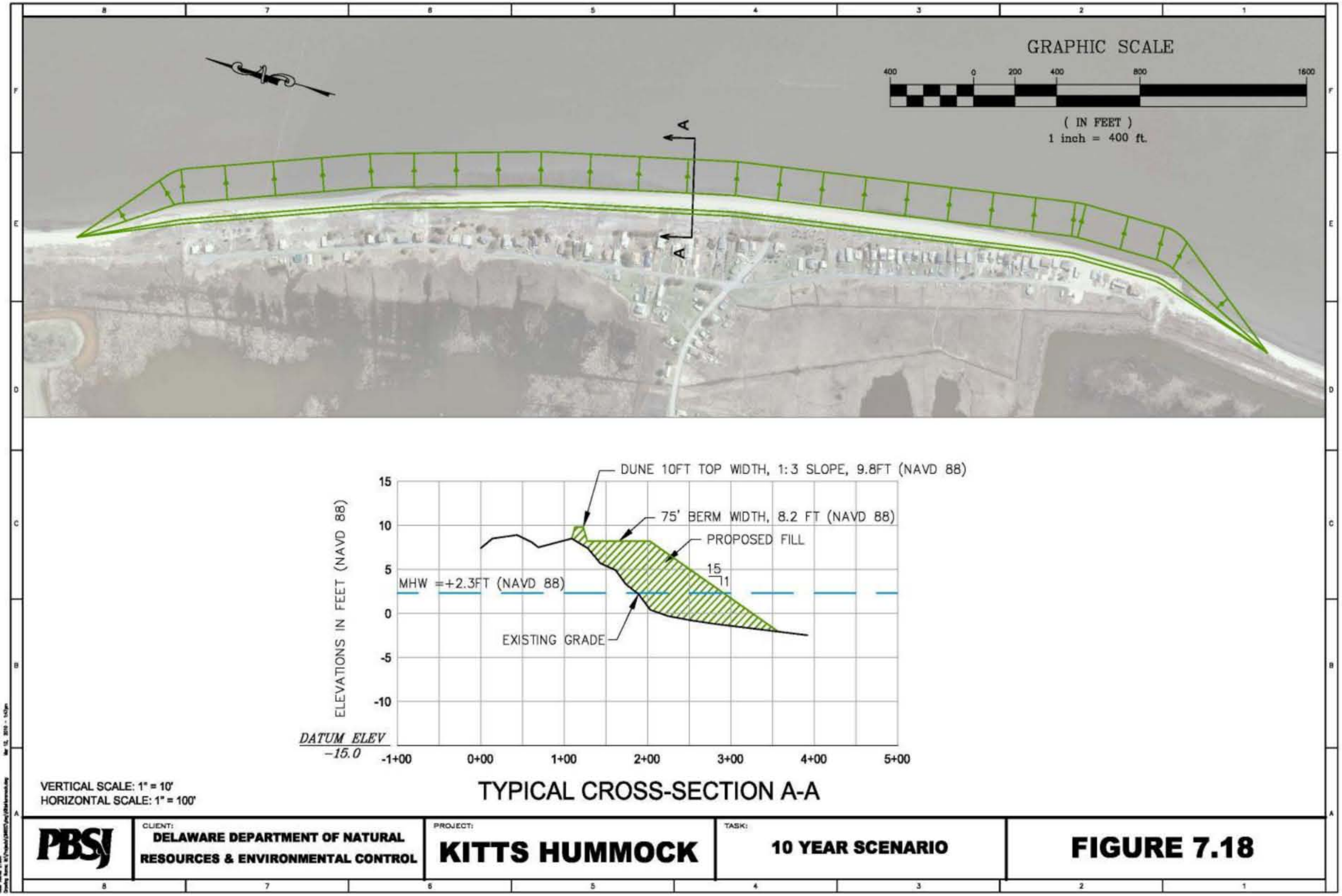
Non-Market Example: Recreational Services of Delaware Bay Beaches

- An example is drawn from a project conducted with the Delaware Department of Natural Resources and Environmental Control (DNREC).
- What is the recreational ecosystem service value gained or lost under different policies to protect Delaware Bay Beaches from erosion due to storms and sea level rise?
- Beaches are: (1) Pickering, (2) Kitts Hummock, (3) Bowers, (4) South Bowers, (5) Slaughter, (6) Primehook, and (7) Broadkill.
- Recreation demand models are used to estimate the value of these beaches under different management scenarios.

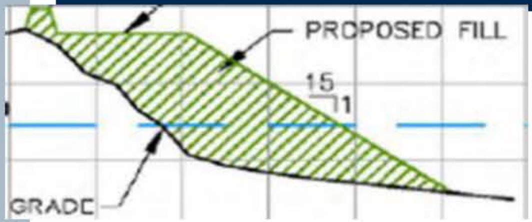
Scoping, Causal Chains and EPFs

- Scoping and causal chain development was conducted in coordination with stakeholders, policymakers and scientists.
- This illustration shows valuation of recreational benefits.
- Engineering projections of beach width and housing loss were provided by Johnson, Mirmiran and Thompson (2012) for each beach, under four management scenarios for 2011-2040. These provided the basis for EPFs.
  - Scenario 1—Beach Nourishment
  - Scenario 2—Managed Retreat
  - Scenario 3—Basic Retreat
  - Scenario 4—Do Nothing

Beach Nourishment - Defined



Enhanced Retreat - Defined



Initially remove structure to allow a beach/dune width equal to the recommended beach nourishment templates for each community.

As additional erosion/shoreline migration occurs, additional structures are removed to maintain this beach width

Basic Retreat - Defined

Initially remove structures to allow a beach/dune width equal to the current widths in each community.

Where existing structures occupy the beach, initial removal occurs .

As additional erosion/shoreline migration occurs, additional structures removed to maintain this beach width.

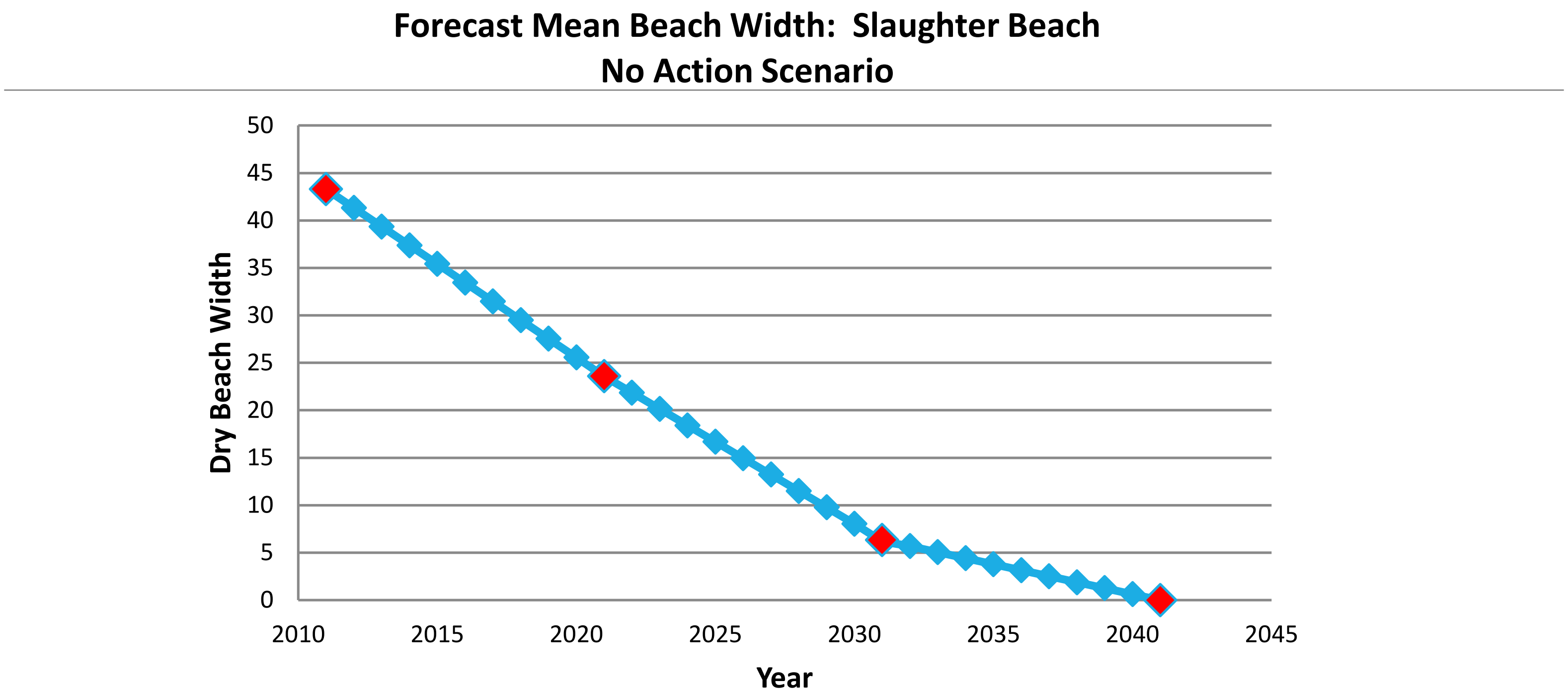
Do Nothing - Defined

This alternative involves no action on the part of state shoreline managers. No beach fill or beach enhancement will occur, historic shoreline migration will cause increasing damage to structures. Houses will be destroyed or removed. Flood insurance is available, and generally covers damage and removal.

Biophysical and Economic Tradeoffs

- Nourishment—recreational benefits increase due to width increases. But this is also the most costly policy.
- Strategic Retreat—Benefits increase due to width increases, but decrease due to large housing losses (forced landward retreat).
- Basic Retreat—Benefits increase due to width increases, but decrease due to modest housing losses (forced landward retreat).
- No Action—Benefits decrease due to width and housing losses. No natural retreat allowed.

EPFs: Projecting Beach Width



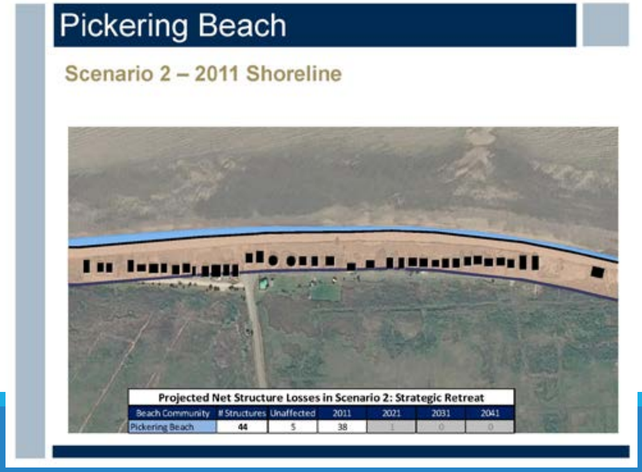
- Mean dry beach widths are forecast for each beach, during each year of the analysis, under each scenario.
- These forecasts are based on beach-specific retreat data from past years combined with sea-level/geomorphology forecasts and scenarios.
- Red points are modeled with interpolations in between.
- Widths at any year can be compared across scenarios to generate the “deltas.”

Estimating Recreational Values

- Recreation demand model estimates annual recreational benefits for each beach at: (1) zero width, (2) current average width, (3) 25% of current width, (4) 200% of current width (Parsons et al. 2013).
- Model is estimated based on observations and survey data from recreationists sampled at each site.
- Random effects Poisson regression predicts trips as a function of beach width, travel cost and other factors
- Tradeoffs between travel cost and trips used to estimate demand & consumer surplus (WTP) under different scenarios for action and beach width.

The Integrated Model

- Model predicts recreational value changes for all beaches, under each scenario, for all years between 2011 – 2041.
- Number of owner and overnight trips is assumed to decline in proportion to loss of standing houses, further reducing benefits.
- The sum of discounted benefits over all time periods (2011 to 2041) is defined as the net present value.
- All values are discounted at a 4% annual discount rate.



Change in Recreational Values Under Alternative Actions

Beach and Visitor Type	Beach Nourishment	Basic Retreat	Enhanced Retreat
Pickering (total)	$659,832	$306,567	$169,168
Kitts Hummock (total)	$625,966	$330,514	$278,198
Bowers (total)	$1,173,049	$579,326	$927,590
South Bowers (total)	$393,726	$82,450	$290,372
Slaughter (total)	$2,391,604	$1,583,761	$2,194,251
Prime Hook (total)	$1,092,704	$63,236	-$365,880
Broadkill (total)	$9,729,112	$7,837,672	$7,268,543
TOTAL ALL BEACHES	**$16,065,994**	**$10,783,525**	**$10,762,243**

Note. All estimates represent Present Value over 2011 to 2041, discounted at 4% and compared to No Action Scenario.

- The table shows changes in non-market recreational values provided by Bay beaches under different adaptation alternatives, compared to a default of No Action.
- Note that this does NOT reflect the costs of each option.

The Big Picture—Economic Tradeoffs

Scenario	(A) Sand, Fill and Demolition (PV, $mill)	(B) Housing Acquisition Payments (paid by State) (PV, $mill)	(C) Housing Acquisition Payments (received by property owners) (PV, $mill)	(D) Recreation (PV, $mill)	(E) Housing Services (PV, $mill)	(F) Reduction in Additional Flood and Erosion Damages (PV, $mill)	(G) Net Benefits (PV, $mill; sum of A through F)	(H) Net Benefits not Including Additional Flood and Erosion Damages (PV, $mill)
Beach Nourish-ment (Scenario 1)	**-$61.1**	**-$0**	**$0**	**$16.1**	**$18.2**	**$2.7**	**-$24.1**	**-$26.8**
Basic Retreat (Scenario 3)	**-$0.5**	**-$61.3**	**$61.3**	**$10.8**	**-$43.1**	**$3.0**	**-$29.8**	**-$32.8**
Enhanced Retreat (Scenario 2)	**-$4.5**	**-$149.1**	**$149.1**	**$10.8**	**-$130.9**	**$10.6**	**-$114.0**	**-$124.6**

Benefit Transfer

- The use of primary research to estimate economic values is almost universally preferred when possible.
- This requires new data and models for the site(s) of interest.
- But, realities of the policy process often preclude the use of primary research to quantify ecosystem service values, leaving Benefit Transfer (BT) as the only option.
- BT uses economic value estimates from existing research (at a study site) to approximate the value of a similar but separate change elsewhere (the policy site).
- BT allows these values to be measured, but includes unavoidable errors.

Main Types of Benefit Transfer

- **Unit Value Transfer** (transfer a number or adjusted number)—Simple but risks large error if study and policy sites are not very similar.
- **Benefit Function Transfer** (transfer a function, usually from one study)—Allows adjustments for some differences between study and policy sites, but accuracy depends on site similarity.
- **Meta-Analysis** (transfer a function calculated from statistical analysis of many studies)—Most flexible approach and does not require site-to-site similarity, but can be sensitive to statistical methods and available studies.

Using Meta-Analysis for Benefit Transfer

Mean Predicted Marginal Value per Fish, by Region and Species							
Species	California	North Atlantic	Mid-Atlantic	South Atlantic	Gulf of Mexico	Great Lakes	Inland
big game	$12.32	$6.19	$5.95	$13.57	$13.26		
small game	$6.38	$5.22	$5.19	$5.03	$4.95		$4.71
flatfish	$8.57	$5.24	$4.94	$4.93	$4.82		
other saltwater	$2.60	$2.62	$2.56	$2.50	$2.44		$2.54
salmon	$13.67					$11.66	$13.88
steelhead	$11.25					$12.57	$11.42
musky						$61.37	$64.71
walleye/pike						$3.61	$3.60
bass						$7.52	$7.92
panfish			$0.93	$0.93		$1.17	$0.93
rainbow trout						$7.38	$2.84
other trout						$8.29	$2.48
generic freshwater						$5.46	$1.96
generic saltwater	$2.73	$2.64	$2.85	$2.51	$3.22		$2.79

- Stapler and Johnston (2009) show how benefit transfers can account for value differences across service types (e.g., types of fish), based on meta-regression models estimated from many prior studies.

Benefit Transfer Errors

- Rosenberger (2015, Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners, Chapter 14) summarizes transfer errors in non-market valuation.

Benefit Transfer Method	Median Absolute Value Error	Mean Absolute Value Error (Std. Err.)	Range of Absolute Value Errors	Number of Studies (N)
Unit Value	45%	140% (10.6)	0-7496%	1792
Benefit Function	36%	65 (4.0)	0-929%	756

Benefit Transfer for Ecosystem Service Valuation

- Methods for ecosystem service benefit transfer are described by Johnston and Wainger (2015, Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners, Chapter 12).
- These methods are indispensable but often misused.
- Factors influencing the applicability of benefit transfer include:
  - (a) the time and resources available; (b) the availability of data for a primary study; (c) policy process constraints;(d) accuracy and other needs of the policy context; (e) the size of policy impacts relative to the cost of a primary study; (f) the availability of primary studies suitable for transfer.

Valuation Toolboxes and Systems

- There are an increasing number of pre-programmed valuation "toolboxes" and decision-support tools marketed for ecosystem services analysis.
- Some are fairly sophisticated, at least with regard to biophysical components (e.g., InVEST)
- However, caution should be exercised in the use of such tools, without knowledge of the underpinnings of the model.
- These tools often use simplistic benefit transfers that fail to account for many factors that may cause values to change over areas, even for a given ecological change.

Some Values Decline with Distance

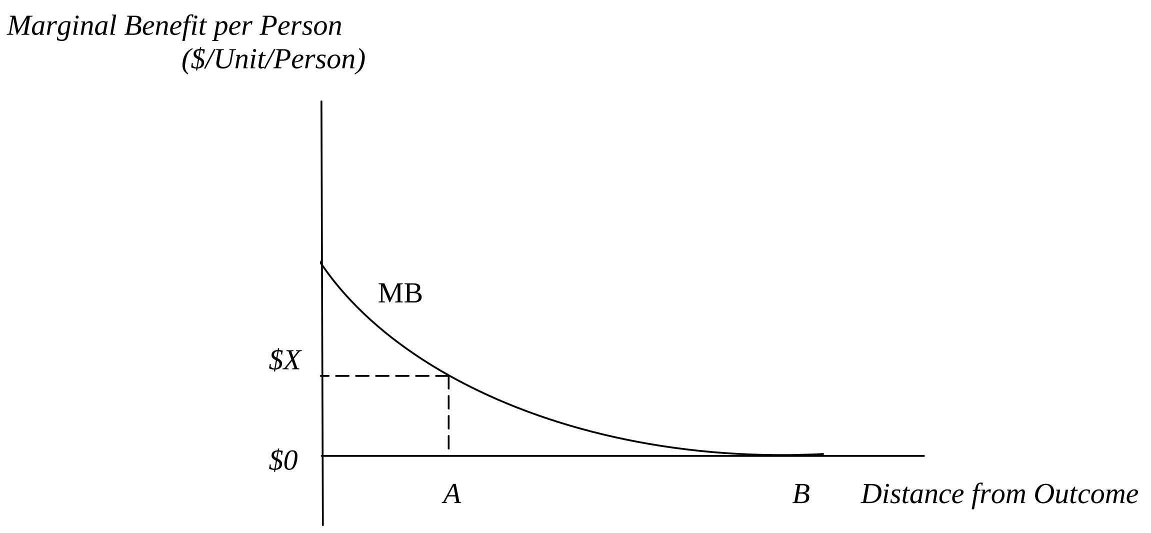
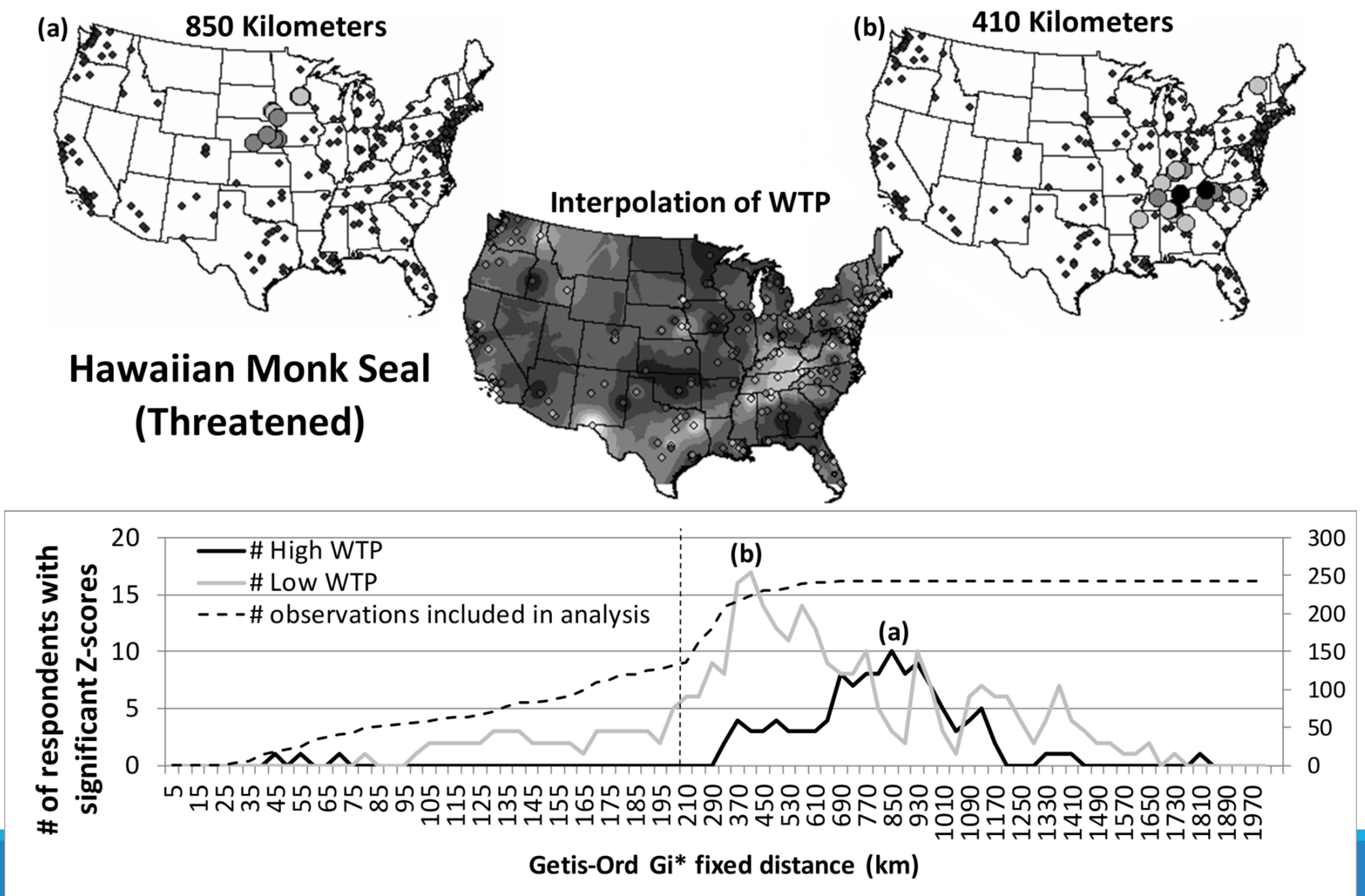


Figure 2.2 Marginal Benefits and Scale over Distance (or Populations Over Greater Areas)

Other Values are Patchy (Johnston et al. 2015, Land Economics)



But Isn't *Some* Number Better than No Number?

- The use of questionable or inaccurate methods to estimate ecosystem values is risky.
  - Can lead to misguided actions and investments.
  - Can lead to perverse or unintended consequences.
  - Can lead to values being discounted or ignored by decision-makers (if they are viewed as widely invalid).
  - Can lead to values (and decisions based on those values) being overturned during legal challenge.
  - Can erode public trust in science and management.

Some Final Considerations

- It is important to involve both natural and social scientists from the outset of the analysis, from question formation through valuation.
- Major errors are often made when analyses seek to "scale up" ecosystem service values measured over small changes or areas to much larger changes or areas.
    - Values change over (1) quantities of an ecosystem service, (2) areas, and (3) affected populations.
- Because of this, it can be challenging to map ecosystem services across the landscape.
- A larger number of ecosystem services (or more of one ecosystem service) are not always better than a smaller number. Consider water levels in a river…

Concluding Comments

- Ecosystem services quantification and valuation can provide information to help ensure that decisions account for the human benefits provided by ecosystems.
- Valuation is particularly important when tradeoffs or costs are involved.
- Validity and accuracy of ecosystem service valuation depends on an application of appropriate methods to well-defined ecosystem services and beneficiary groups.
- Ecosystem service valuation requires an understanding of the causal chain linking actions to BRIs to benefits.
- Relevant valuation methods depend on the type of values to be measured.

Concluding Comments

- Different types of values can be measured, depending on the goals of the analysis and the type of ecosystem services under consideration.
- Ecosystem service values generally change over different areas, beneficiaries and service quantities. Accurate valuation should account for these differences
- Primary valuation or benefit transfer can be used, depending on the policy context, accuracy needs and data availability.
- Be cautious of valuation toolboxes or tools, without an understanding of the underlying methods.
- Inaccurate value estimation can lead to decisions with perverse and unintended consequences. “A Big Number” can be a bad idea if the number is meaningless or (badly) wrong.

Questions?

Robert J. Johnston
Director, George Perkins Marsh Institute
Professor, Department of Economics
Clark University
950 Main St.
Worcester, MA 01610
Phone: (508) 751-4619
Email: rjohnston@clarku.edu

CLARK UNIVERSITY