Ensuring the Joint Ecological and Economic Salience of Ecosystem Service Values: An Application to Riparian Restoration

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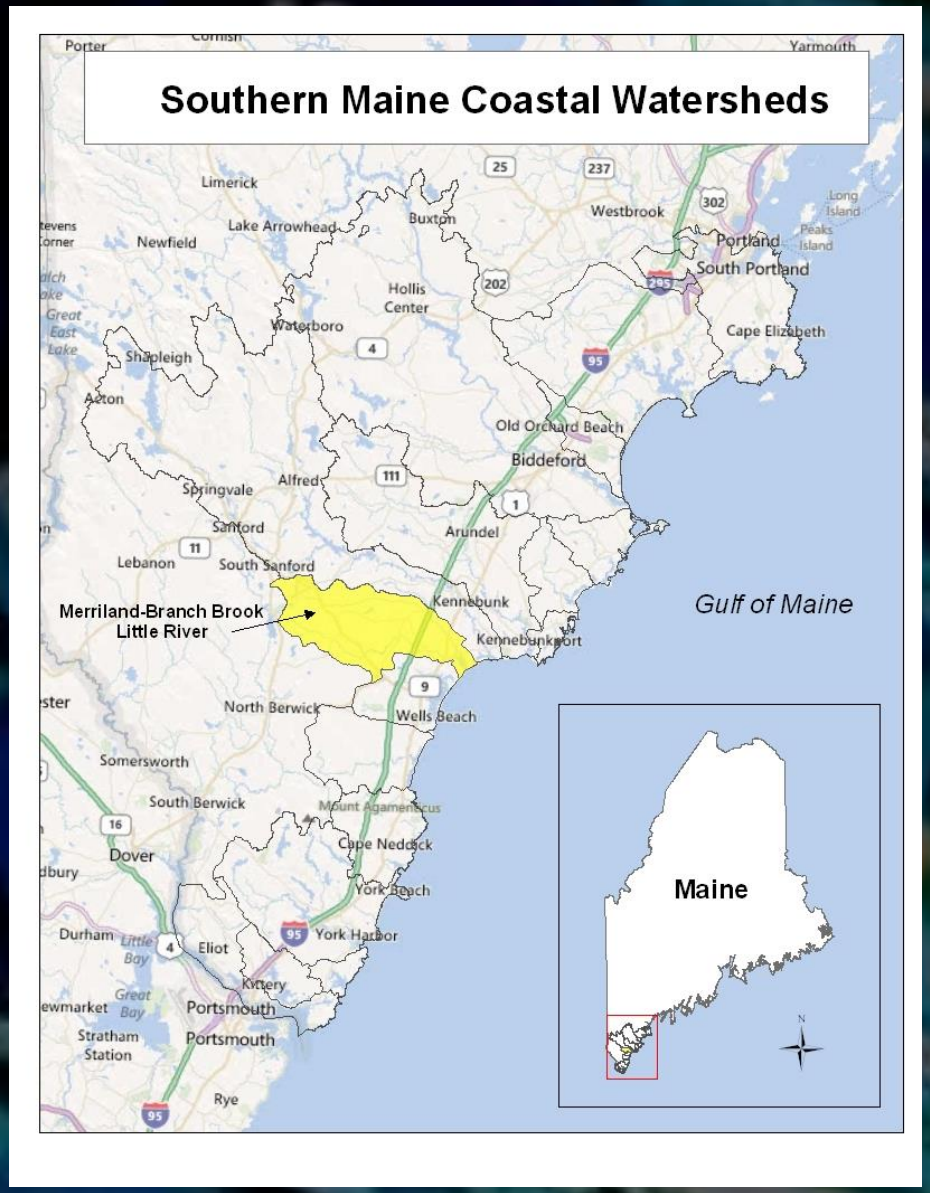
Estimating Defensible and Salient Values

- The salience of ecosystem service (ES) values depends on the validity, precision and applicability of all methods and data—both ecological and economic.
- This presentation discusses the methods and challenges involved in disentangling aquatic ES and estimating defensible values, with coupled interdisciplinary fieldwork.
- Methods are illustrated using a case study of riparian land restoration in the Merriland, Branch Brook, and Little River (MBLR)Watershed of south coastal Maine, USA.
- Values are estimated using discrete choice experiments developed in tandem with ecological data and modeling.
- Objectives included valid and transparent measures of value linked to measurable, site specific-biophysical outcomes.

Study Location



Project Components

- The project was characterized by joint development and implementation of economic and ecological components.
- Research with stakeholders, natural scientists and the public to identify final ES expected to change as a result of riparian land restoration in the MBLR watershed.
- Development of coupled ecological and economic frameworks / models to quantify and value these ES.
- Ecological fieldwork and modeling to quantify status and forecast potential changes in ES.
- Development, testing and implementation of economic choice models to quantify preferences and values.
- Coordination of results to forecast ES value implications of riparian land scenarios.

Economic Choice Experiments

- Economic values and tradeoffs are quantified using discrete choice experiments.
  - Survey-based methods that estimate values from respondents' votes over different policy options.
- Questions modeled as public votes. Respondents choose among policies with different effects and costs.
- By evaluating votes over many different alternatives, we calculate tradeoffs that reveal values (willingness to pay).
- Can also be used to predict results of binding referenda.
- Results enable discovery of the biophysically possible tradeoffs that are most highly valued by residents.

Developing the Choice Experiment

- Discrete choice experiment scenarios and surveys were developed through a three year process.
  - Focus groups / interviews with the public and stakeholders to identify primary, final ecosystem services affected by changes in area riparian land that benefit the public.
  - Development of framework linking these services to measurable indicators, then to human values.
  - Ecological field research to quantify biophysical changes and evaluate causal linkages.
  - Choice scenarios are grounded in the biophysical status quo and feasible changes characterized by ecological data and model results.
  - Extensive pretesting and revision of survey instruments.

What Methods and Outcomes of Riparian Land Restoration Have Value?

- Process identified methods and ES outcomes that were directly valued by the public, and expected to change due to local riparian land restoration or conservation.
  - Natural vegetation cover on riparian land (measured using a remotely-sensed land use index).
  - Water quality and ecological condition (measured using aquatic biotic index calculated by Wells NERR ecologists, with changes predicted using river sampling data).
  - Recreational fish abundance (measured using an index of brook trout abundance from electrofishing samples).
  - Swimming safety of local beaches (measured using beach water quality tests passing safety guidelines).
  - Development restrictions (development setbacks and enforcement provisions).

The Choice Experiment Survey

CHOICES FOR OUR LAND AND WATER

A Survey of Kennebunk, Sanford and Wells Residents

Sponsored by the Wells National Estuarine Research Reserve and Clark University

LAND AND WATER IN SOUTHERN MAINE

What happens on land in Maine affects its rivers and streams. **The area where land meets the water is called riparian land.** Riparian land within **300 feet** of the water is considered most important by scientists.

Natural Riparian Land

Partially Cleared Riparian Land

Natural riparian land in southern Maine is forested, with trees and low-level plants. This land provides a number of services. For example, riparian land:

- **Filters out pollutants** before they reach the water
- **Prevents erosion** and collapse of river banks
- **Prevents flooding** of homes and property by absorbing flood waters
- **Improves habitat** for fish, birds and other wildlife
- **Provides natural scenery** for residents and visitors.

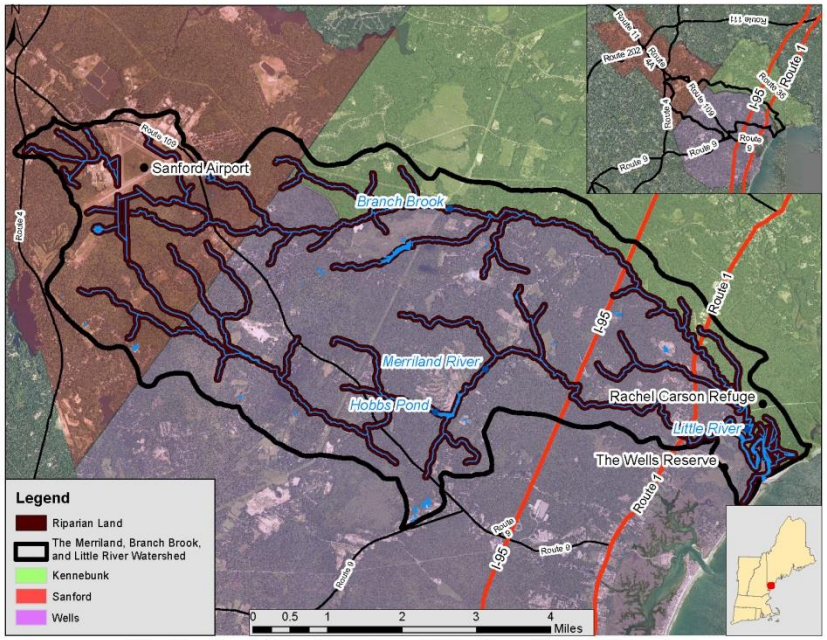
When this land is cleared or developed, many of these services decline.

This survey asks for your opinions about how riparian land is managed in areas surrounding the Merriland, Branch Brook, and Little Rivers in your area.

Your answers will help public officials and nonprofit organizations decide how to manage this land.

RIPARIAN LAND IN KENNEBUNK, SANFORD AND WELLS

The map below shows the area addressed by this survey. This includes all land that drains into the **Merriland, Branch Brook**, and **Little Rivers** within Kennebunk, Sanford and Wells.

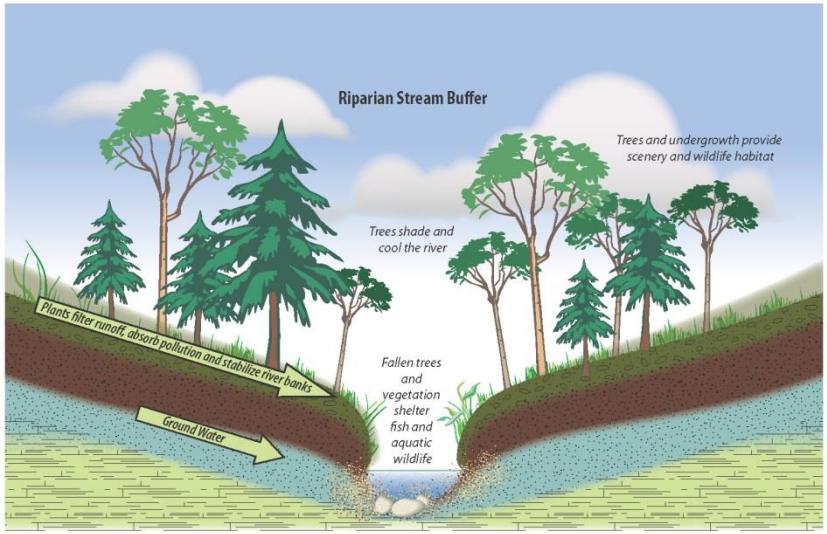


The Merriland, Branch Brook, and Little River (MBLR) Watershed

Across this area there are about **4,700 acres** of land within 300 feet of a river or stream. This area is shown as Riparian Land on the map. **4,300 acres** of this riparian land are covered by trees and natural vegetation. The remaining 400 acres have been developed or cleared.

WHAT RIPARIAN LAND DOES

The figure below illustrates some of the main natural services provided by riparian land, such as absorbing pollution, improving wildlife habitat and providing natural scenery.



Natural Services of Riparian Land

Development in Kennebunk, Sanford, and Wells is removing trees and vegetation on more riparian land each year. This is affecting scenery, river ecosystems, fish, and water quality. Because of this, some people have called for additional restrictions on clearing and development of this land. At the same time, other people do not want the development rights of private landowners to be further restricted.

COMPARING PROTECTION OPTIONS

The upcoming questions will ask you to compare different ways of protecting riparian land in Kennebunk, Sanford and Wells, and vote for the ones you prefer. You may also vote to reject the proposed programs and retain the status quo. **Effects of each option will be described by the following effects, as estimated by scientists:**

Effect	What it Means
Natural Riparian Land	The amount of riparian land covered by natural vegetation. Currently about 91% of the land is in natural condition. With no action **85%** of riparian land in the area (4000 acres) will remain in natural condition in 5-10 years.
River Ecology	Average ecological condition of area rivers, measured by the diversity of small organisms (dragonflies, mayflies, etc.) that live there. A score of 100% is the best possible condition in the area. A score of 0% means nothing lives in the water. With no action, the ecological condition in area rivers will be **55%** in 5-10 years. The score today is about 60%.
Recreational Fish	The number of recreational fish in area rivers, measured by scientific sampling of brook trout. A score of 100% would mean that area rivers contain the maximum number of trout possible (30 trout per 1000 sq. feet). Today there are about 19 trout per 1000 sq. feet. With no action, scientists predict there will be an average of 17 trout per 1000 sq. feet (**55%** of the most possible) in 5-10 years.
Safe Swimming	The percentage of days in which government tests show that area beaches (Laudholm, Drakes Island, Crescent Surf, and Parson) are safe for swimming. 100% means that all tests show water safe for swimming. With no action, scientists predict **85%** of tests will show water safe for swimming in 5-10 years.
Development Setback	The minimum width of the riparian area where development is restricted. Currently development and clearing is restricted within a minimum distance of **100 feet from rivers** and **25 feet from streams**. This distance is larger in some areas and for some types of development. Existing (legal) development would be grandfathered if setbacks change.
Enforcement	Whether enforcement is increased to prevent illegal development or clearing on riparian land. This could include inspections on private land if violations are suspected. Currently, inspections can only occur when a violation has been reported or as part of permitting.
$ **Cost to your Household per Year**	How much the policy will cost your household in unavoidable annual taxes and fees. These are guaranteed to only be spent on the protection option that is indicated.

QUESTION 5

OPTION A and **OPTION B** are possible protection options for the area surrounding the Merriland, Branch Brook, and Little River. The current situation is the status quo with **NO NEW PROTECTION**.

Given a choice between the three, how would you vote?

Method or Effect of Protection	In 5-10 years under the Current Situation	In 5-10 years under Option A	In 5-10 years under Option B
Riparian Land Condition	**85%** 4000 out of 4700 riparian acres covered by natural vegetation	**87%** 4100 out of 4700 riparian acres covered by natural vegetation	**90%** 4200 out of 4700 riparian acres covered by natural vegetation
River Ecology	**55%** of best possible (100%) ecological condition	**75%** of best possible (100%) ecological condition	**75%** of best possible (100%) ecological condition
Recreational Fish	**55%** 17 out of 30 possible fish per 1000 sq. feet	**65%** 20 out of 30 possible fish per 1000 sq. feet	**65%** 20 out of 30 possible fish per 1000 sq. feet
Safe Swimming	**85%** of beach tests meet safe swimming guidelines	**90%** of beach tests meet safe swimming guidelines	**90%** of beach tests meet safe swimming guidelines
Development Setback	**100 feet** required between development and rivers; 25 feet for streams	**100 feet** required between development and rivers; 25 feet for streams	**200 feet** required between development and rivers; 125 feet for streams
Enforcement	**No Change** in enforcement and inspections	**No Change** in enforcement and inspections	**No Change** in enforcement and inspections
$ **Cost to your Household per Year**	**$0** Increase in Annual Taxes or Fees	**$45** Increase in Annual Taxes or Fees	**$30** Increase in Annual Taxes or Fees
HOW WOULD YOU VOTE? (CHOOSE ONLY ONE) **I vote for**	☐ **NO NEW PROTECTION**	☐ I vote for **OPTION A**	☐ I vote for **OPTION B**

Design, Implementation and Modeling

- Surveys implemented December 2013 – January 2014.
- Random sample of Kennebunk, Sanford and Wells residents. Multiple wave mailings to maximize response.
- Of 3,460 deliverable surveys, 1,223 were returned for a response rate of 34.5%.
- Model estimated using random parameters (mixed) logit. Accounts for panel data and preference heterogeneity.
- All ecological attributes included in percentage form, relative to the ecological reference condition for the watershed (100%).
- All percentages can be linked to measurable, cardinal changes in ecological indicators or indexes.

Raw Model Results

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Chi squared [  13 d.f.]      1174.99325
Significance level               .00000
McFadden Pseudo R-squared      .2411012
Number of obs.=  2218
--------+-------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
        |  Coefficient       Error       z    |z|>Z*         Interval
--------+-------------------------------------------------------------------
        |Random parameters in utility functions
NEITHER |   -3.26424***      .51291    -6.36  .0000    -4.26952  -2.25896
FISH_PCT|     .04075***      .00596     6.84  .0000      .02907    .05243
SWIM_PCT|     .07220***      .01322     5.46  .0000      .04629    .09811
SETBACK_|     .00541***      .00182     2.98  .0029      .00185    .00897
ENFORCE |     .64542***      .11486     5.62  .0000      .42031    .87054
NEG_COST|     .04932***      .00504     9.80  .0000      .03945    .05919
        |Nonrandom parameters in utility functions
LAND_PCT|     .07392***      .01680     4.40  .0000      .04099    .10685
WATER_PC|     .04546***      .00566     8.03  .0000      .03436    .05656
        |
        |Distns. of RPs. Std.Devs or limits of triangular
    NsNE|    6.70172***      .67433     9.94  .0000     5.38006   8.02337
NsFISH_P|     .03404*       .01758     1.94  .0529     -.00042    .06849
NsSWIM_P|     .05711        .03967     1.44  .1499     -.02063    .13486
NsSETBAC|     .02565***      .00370     6.94  .0000      .01840    .03289
NsENFORC|    1.07711***      .25742     4.18  .0000      .57258   1.58165
TsNEG_CO|     .04932***      .00504     9.80  .0000      .03945    .05919
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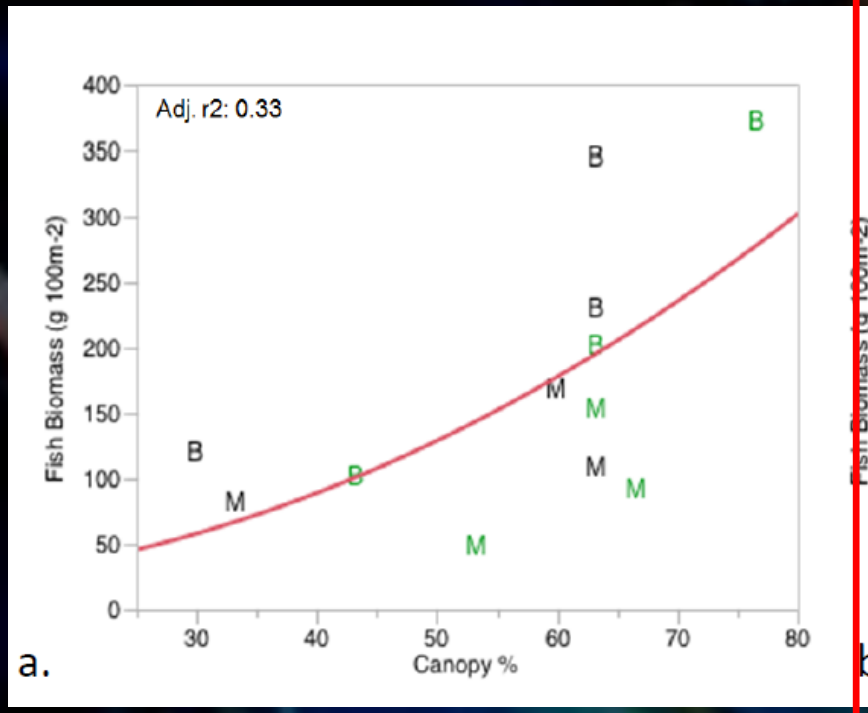
Ecosystem Service Values (marginal)

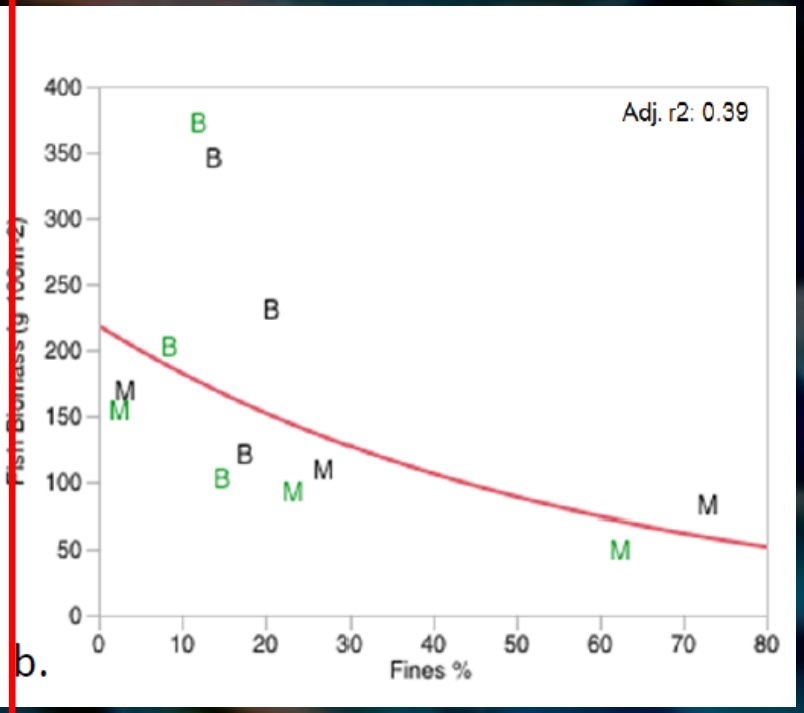
Attribute	Description	Value (per unit, per household, per year)
Land Condition	Δ in natural land cover (% of riparian land with natural canopy)	$2.05 ($0.043 / acre)
River Condition	Δ in aquatic ecological condition (% on 100 point aquatic biotic index).	$1.28
Recreational Fish	Δ in recreational fish abundance (% of reference condition for watershed)	$1.15 ($3.83/fish/1000 sq. ft.)
Swim Safety	Δ in beach tests passing water quality safety guidelines (% of tests).	$2.02
Setbacks	Δ in required setback between development and rivers (feet).	$0.14
Enforcement	Increases in enforcement and inspections (0-1)	$17.31

Applying the Integrated Model

- The model can be used in multiple ways to quantify and illustrate ecosystem service values.
- Calculations of total value change must account for the fact that ecosystem service changes are causally related.
- To illustrate one possible application, we use integrated results to forecast ES values that would result from a 5% (or 235 acre) increase in naturally vegetated riparian land in the MBLR Watershed.
- Accounts for correlations established using data from ecological field studies.

Linking Riparian Land and Recreational Fish





In both the Merriland River (M) and Branch Brook (B) for both open (black font) and forested (green font) sites, fish biomass is significantly positively correlated with percent canopy cover (a) and significantly and negatively correlated with the percentage of fine sediments in the system (b).

Forecasting Ecosystem Service Values (per household, per year)

Attribute	Status Quo	Proposed Restoration
Land Condition	85%	90%
River Condition	55%	No change forecast
Recreational Fish	55%	67.35% *
Swim Safety	85%	No change forecast
Setbacks	100	100
Enforcement	No Change	No Change
Added Value per Household per year	$0	$24.45

* Each 1% increase in riparian land tree canopy cover is associated with a 2.47% increase in brook trout abundance.

Integration Challenges

- The time and effort required to develop integrated approaches can be considerable.
- Results may not always match expectations.
  - Ecologists expected to find some biophysical patterns that could not be verified.
- Some other effects that might be valued (rare wildlife abundance) were not expected to change due to small-scale changes in local riparian land cover.
- Results must be interpreted with respect to both local values and quantifiable biophysical changes.
- Sometimes people want to find values where they cannot be verified or measured.

Summary Points

- Project included extensive involvement of natural and social scientists from project inception to completion.
- Fundamentally coupled approach—economic valuation informed ecological data/models and vice versa.
- The goal is values that are salient and defensible from both an economic and ecological perspective.
- All values are grounded in field data and well-defined indicators.
- Values can be tracked transparently from policy actions to ecological changes to economic values.
- Results enable forecasting of economic benefits for a wide range of potential policy interventions.

Questions?

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