Measuring and Monitoring the Economic Effects of Habitat Restoration: A Summary of a NOAA Blue Ribbon Panel

5/13/2010

prepared by

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In partnership with Restore America's Estuaries

With funding from the National Oceanic and Atmospheric Administration's Restoration Center and Assessment and Restoration Division

Author's note: This report benefited greatly from comments by Jeff Benoit, Anthony Dvarskas, Peter Edwards, Steve Emmett-Mattox, Kenneth E. 'Ted' McConnell, Steve Newbold, George Parsons, Tony Penn, Steve Polasky, Randall S. Rosenberger, Suzanne Giles Simon, Douglass Shaw, and Kristy Wallmo. Many of the ideas in this document are from these reviewers. All errors and omissions are those of the author.

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1. Why Monitor and Measure the Economic Effects of Restoration?

Restoring degraded marine and coastal habitat is critical if America's coasts and oceans are to reach their economic and ecological potential. NOAA and its partners in the Estuary Restoration Act Council have a number of programs, including the Damage Assessment Remediation and Restoration Program (DARRP), the Restoration Center (RC), and the Assessment and Restoration Division (ARD) that are dedicated to restoring coastal, estuarine, and marine habitats. NOAA works in partnership with other federal agencies, nonprofit organizations, state and local governments to identify and fund restoration projects around the country.

Because the focus of NOAA's restoration efforts has been on restoring the ecosystem functions of degraded and damaged habitats, the agency has used biological and ecological metrics – for example the number of stream miles and acres restored to natural conditions, to measure the success of restoration activities. Economic metrics have not routinely been used to measure and monitor the effects of restoration activities, although many such measures were recommended by Salz and Loomis (2005). Without good economic measures of the realized effects of restoration, NOAA and its sister agencies are generally unable to show how restoration projects have changed the economic use and value of the habitats restored. Further, managers require good information on the economic effects of restoration in order to choose among alternative projects and to design and evaluate national and regional habitat restoration programs.

There is new interest at NOAA, and other agencies involved in restoration, to find ways that demonstrate how restoration projects affect local economies and the overall economic well-being of the country (Murawski 2009). Internally, NOAA's science advisory board (SAB) recently recommended that the agency use "social science analysis to demonstrate and calibrate its accomplishments" (SAB, p.6, 2009) and also to use "social science to identify and measure social and economic outcomes" (SAB, p.8, 2009). The SAB recognizes that in Congress, and in the public forum, people want tax dollars spent on restoration to have a positive effect on the local, regional, and national economies.

Interest in harnessing the economic potential of coastal habitat exists even at the White House level. President Obama's Interagency Ocean Task Force's proposed National Ocean Policy cites that "current and future uses of ocean, coastal, and Great Lakes ecosystems should be managed and effectively balanced in a way that maintains and enhances the environmental sustainability of multiple uses, including those that contribute to the economy…" (CEQ, p.15, 2009). The White House Council on Environmental Quality also proposed new draft principles for water resources planning projects that would direct the development of "water resource projects based on sound science that maximize net national economic, environmental, and social benefits" (CEQ P&G 2009). These new planning standards include the directive to "account for the national benefits and costs [of water resource projects] in appropriate monetary and non-monetary terms" (CEQ P&G 2009).

In 2009, the importance of restoration to local economies was recognized by the allocation of $167 million in funds from the American Recovery and Reinvestment Act (ARRA) for coastal and marine habitat restoration. These ARRA funded projects were chosen in part to create new jobs and in part to provide economic benefits to local and regional economies through the provision of market and non-market ecosystem services. Despite this unprecedented investment in habitat restoration, these funds are likely to be insufficient to restore all of the nation's estuaries and coasts to a level that will achieve their optimal economic value. As a sign of the demand for restoration funding, the amount of money requested in applications was more than ten times greater than the available funds.

Finding ways to determine the economic effects of restoration activities is a critical first step in showing how restoration can improve the economic wellbeing of the nation. It can help determine the appropriate level of funding for restoration, choose the best restoration projects, and could be used to design better restoration projects that include economic, as well as ecological goals. The appropriate and optimal level of funding for habitat restoration depends in part on the economic value of restoration.

2. A Blue Ribbon Panel for Estuary Economics

Unlike the commercial fisheries arm of the National Marine Fisheries Service (NMFS – Office of Science and Technology), restoration agencies have not historically collected systematic data on the economic outcomes associated with their activities. As a result, it is difficult for NOAA's restoration programs to argue convincingly that their work has economic relevance.

One reason for the absence of this kind of data collection has been because it has not always been obvious what data should be collected, how it should be collected, and whether it could be analyzed in a way that would have a high likelihood of demonstrating empirically the effect of restoration on economic outcomes.

Because there has never been a systematic effort to collect data to measure and monitor the effects of coastal habitat restoration on economic value, in December 2009, Restore America's Estuaries, in concert with the NOAA, convened a Blue Ribbon Panel of economists to consider approaches for collecting and analyzing data on the economic outcomes of selected restoration projects. The Panel was asked to provide recommendations on what aspects of economic outcomes could be measured to best capture the economic value and impacts of restoration projects. The Panel also was asked to provide recommendations on how these outcomes could be measured and analyzed and what types of restoration projects NOAA might first attempt to monitor for economic outcomes. The full list of panelists and their affiliations are given in Table 1.

Table 1. Blue Ribbon Panel on Estuary Economics, December 2009, Washington, D.C.

Panelist	**Affiliation**
Kenneth E. 'Ted' McConnell	University of Maryland
Steve Newbold	U.S. Environmental Protection Agency
George Parsons	University of Delaware
Linwood Pendleton	Duke University
Steve Polasky	University of Minnesota
Randall S. Rosenberger	Oregon State University
Douglass Shaw	Texas A&M University
Kristy Wallmo	NOAA

This document summarizes the recommendations of that panel. It is intended to be a starting point to help NOAA, its sister agencies, and its restoration partners consider systematic approaches for the collection of data to measure and monitor the economic outcomes of habitat restoration in the coastal zone. The panel suggested that the process of developing such a system of data collection should be an iterative one in which methods are applied, tested, and refined. We provide a summary of the basic recommendations of the panel and note differences in opinions among the panel when appropriate. We begin by providing a brief overview of key concepts. The remainder of this paper is organized as follows. In Section 3, we discuss the basic principles that should guide the selection of metrics for monitoring the economic effects of habitat restoration. In Section 4, we review the panel's suggestions regarding what data could be collected to monitor and measure the economic outcomes of restoration. In Section 5, we outline a potential approach to collecting long-term systematic data to monitor and measure the economic outcomes of restoration (assembled from suggestions made by the panel). In Section 6, we discuss NOAA's capacity for conducting data collection and analysis on restoration outcomes; and in Section 7, we consider how collecting such data could influence how NOAA chooses restoration projects.

3. Metrics for Measuring and Monitoring the Economic Effects of Restoration Projects: Economic Values and Economic Impacts

Economic Value

Estuary and coastal ecosystems provide many goods and services that society values. These ecosystem services include providing habitat for finfish and shellfish that are harvested directly from these ecosystems by commercial fishers and recreational anglers. Estuaries and rivers also serve as nurseries and reproductive areas for many estuarine and marine fisheries. Hunters and birdwatchers visit coastal areas to find birds, mammals, and other wildlife that thrives in coastal ecosystems. Hikers, swimmers, and other recreational users of coastal and estuarine areas find that their enjoyment often depends on the ecological and environmental condition of these areas. Property values have been shown to reflect ecosystem and environmental quality in coastal and estuary ecosystems (see Kildow 2008 for a review of the literature). Ecological conditions in coastal and estuarine ecosystems have been shown to influence the value of commercial and recreational activities and tourism. Finally, coastal ecosystems provide a variety of other services including shoreline protection, flood control, and the ability to store carbon. All of these ecosystem services provide potential value to local, regional, national, and international economies.

Habitat restoration can create economic value if it produces new ecosystem services that did not exist prior to restoration or if it increases the value of existing ecosystem goods and services or the value of other economic activities that depend on ecosystem conditions. If the total increased value exceeds the costs of restoration, then it can be considered that the restoration had net economic benefits to society.

On a project level, economists measure value by examining what is created by a project, the maximum amount society (or members of society) would pay for what is created, and how much the project costs. This could be the willingness to pay for new ecosystem goods or services (e.g., recreational opportunities), the willingness to pay for improved ecosystem goods and services (e.g., improved water quality), or the willingness to pay to avoid further loss and degradation of ecosystem services (e.g.,, retaining unique habitats). The difference between the maximum amount that society would be willing to pay for a project's outcomes and its costs reveals its net economic value to society — a measure of the change in societal welfare. The willingness of society to pay for the project divided by the cost captures what economists call the rate of return on the project; i.e., the per unit value returned per unit cost invested. Both net economic value and rate of return are measures often used to compare the economic outcomes of projects. The same concepts can be applied to restoration programs made up of suites of projects.

Net economic value is the measure used in benefit-cost analysis (like that proposed in the revised CEQ Principles and Guidelines for water projects) and for trade-off analysis (like that proposed in the CEQ's Draft Interim Framework for Coastal and Marine Spatial Planning). Because costs and benefits can be spread unevenly over a wide geography and over many years, the calculation of net economic value depends on whether one's perspective is local, regional, national, or international. Similarly, the net economic value of a project or program depends on how far into the future one wants to consider project costs and benefits and how we weight the future against the present; i.e., the appropriate discount rate.

The challenge with understanding, measuring, and monitoring the economic value of habitat restoration lies in the fact that economic values of estuary and coastal ecosystems, and thus the economic outcomes associated with restoration, are not always easy to quantify. Project outcomes include direct market effects (e.g., people might be willing to pay to visit a restored area), indirect market effects (e.g., restoration could increase commercial fishing harvest by providing more or better nursery habitat), non-market effects (e.g., the recreational value of fishing in a restored estuary, enjoying the view offered by a restored area or knowing that an endangered species exists because of habitat restoration) and offsite effects (e.g., restoration can result in reduced sedimentation in downstream areas of estuaries, increased property values).

To carefully measure the economic outcomes of restoration projects and programs, economists need to characterize the basic components of economic value associated with the ecosystem that is restored. These include:

1) Use value – the maximum willingness of society to pay for the direct or indirect use of a coastal ecosystem.

2) Non-use (passive) value – the maximum willingness of society to pay for the existence of or improvement in an ecosystem, now or in the future.

Together, use and non-use values represent the Total Economic Value of an ecosystem good or service. (Go to www.csc.noaa.gov/coastal/economics/envvaluation.htm for more information on total economic value.)

Use values include both direct and indirect uses of natural resources. Use values can include extractive values, where the user takes something from the ecosystem (e.g., oyster harvesting) or non-extractive uses (e.g., birdwatching). Use values can be: marketed directly and thus have a direct market value (e.g., oysters can be sold at market); they may not be marketed directly, but could affect the market value or price of an associated activity (e.g., the cost of a day of charter fishing, the cost of a bayside hotel room, or the value of a home); or may fall almost entirely outside of the market (e.g., the use value enjoyed by pedestrians along a public boardwalk). It is important to note that use values can be enjoyed by consumers and producers. The net use value for someone who enjoys a coastal ecosystem good or service for personal use, for instance, is measured as the consumer surplus – the amount the consumer is willing to pay to use the ecosystem beyond what they have to pay to use it (e.g., parking fees, costs of traveling to the estuary, etc.). Producers also have a willingness to pay to use the ecosystem (e.g., to harvest oysters). The net economic use value for producers – their producer surplus – is the revenue generated from using the resource (e.g., harvesting oysters) minus the costs of resource use.

Non-use or passive use values can accrue to users and also people who have never seen or visited an estuary ecosystem by valuing its existence without the intent to visit (existence value), valuing the option to be able to visit it in the future (option value), and/or valuing future generations' options to visit it (bequest value). These are real economic values; they can be influenced by restoration, and should be considered when weighing the costs and benefits of restoration.

When considering the economic value of restoration, it is important to remember that these values depend entirely on the preferences people have for ecosystem goods and services. Different people prefer different aspects and uses of coastal ecosystems. These values also depend on people's potential willingness to pay for these ecosystem goods and services, which depends on their ability to pay (which is determined in part by their income and wealth).

The value of restoration is limited to the change in ecosystem value that can be attributed to the restoration project or program. The net economic value of habitat restoration is this change in value minus the costs of restoration including any in-kind costs (e.g., the value of donated land). Because most of the costs of restoration are accounted for directly by restoration managers, the Panel was asked to focus specifically on providing recommendations about methods and approaches for measuring the values (benefits) of restoration.

A more complete explanation of the economic value of coastal ecosystem services can be found in the new book **Economic Analysis for Ecosystem-based Management: Applications to Marine and Coastal Environments** (Holland et al. 2010).

Economic Impacts: Spending

One outcome of habitat restoration is the infusion of money into local economies. These expenditures can be used to estimate economic impacts of the restoration on a local economy. The Panel noted that measures of economic impact do not accurately reflect economic value and should not be considered a metric of value. In benefit-cost analysis, wages and project spending are accounted for as project costs. (See the Appendix for an explanation of why job creation and economic value are not the same.)

4. Data and Analysis for Determining the Influence of Restoration on Economic Value

To understand the effects of a restoration project on economic value, the analyst needs to know exactly how value differs as a result of the restoration, compared to what that value would have been without the restoration. Ideally, the Panel suggested the analyst ought to have two kinds of data:

1) ecological performance data—how much did the restoration improve the ecosystem goods and services valued by humans; and

2) economic outcome data – how much did the willingness to pay for these goods and services change due to restoration.

Historically, NOAA has used "miles of stream restored" and "acres of wetland restored" as the basic measures of ecological outcome. The value of a stream mile or wetland acre restored depends on certain attributes of those stream miles and restored acres. Data on stream miles and acres restored alone are insufficient to estimate the economic value of a restoration project or program. The specific ecological outcome measures of restoration that would be needed to estimate the economic value of restoration will depend on the habitat restored, how people will use that habitat or indirectly benefit from the ecosystem services it provides, and what attributes of that habitat might generate non-use value.

Even without a complete accounting of ecological and environmental change, it may be possible to show that a restoration event has had an impact on a target economic use or value. An ecosystem or environmental change does not necessarily translate to a discernable change in value. For instance, increasing fish abundance if fish are already highly abundant may have only an incremental and small effect on economic value (Dunford *et al.* 2004). A change in economic value alone also does not conclusively demonstrate that the restoration project or program is responsible for the change in value; other, unexplained factors could have occurred at roughly the same time and place as a restoration event, and these factors, not restoration, may account for all or part of the change in value (e.g., changes in human populations, awareness of ecosystems, or the economy).

To empirically show that restoration has created value, the analyst needs to be able to accurately isolate the effects of restoration from other factors and provide convincing evidence (e.g., a survey in which people indicate that the ecological attributes restored matter to them) that the ecological and environmental outcomes of restoration are indeed the causes of these changes in value (see for instance (Barbier, 2007; Fisher et al., 2008).

Measuring the Effect of Restoration vs. Estimating the Potential Value of Restoration

To understand and measure whether habitat restoration has had an effect on economic value and what that effect might be requires comparing the value of ecosystem goods and services with and without the restoration.

To date, a substantial body of literature exists that discusses and applies methods for estimating the potential economic value of habitat restoration and change in coastal, estuarine, and wetland ecosystems. These valuation methods are generally of two types: revealed preference (RP) methods and stated preference (SP) methods. RP methods are distinguished by their use of data on observed behaviors in real-world choice situations, as opposed to stated preference methods, which use data consisting of responses to hypothetical questions. RP methods estimate the potential economic value of a restoration project by examining how values differ at sites with and without restoration (or with and without some specific ecosystem attributes associated with restoration). These methods include travel cost studies (simple travel cost, and multiple site travel cost) and many methods that examine the effect on home values of differing ecological or environmental conditions (called hedonic methods). SP methods elicit people's willingness to pay for the kind of improved ecological conditions that are predicted to result from restoration. One's maximum willingness to pay is found by asking questions in the context of a constructed or hypothetical market in which restoration values can be traded-off against other values that often are measured in terms of dollars or some other currency. SP methods include the standard contingent valuation method, but also include stated choice modeling approaches. These valuation methods are particularly important in helping managers understand the potential value of proposed restoration policies. These methods do not demonstrate – after the fact – that these values did indeed change due to habitat restoration. For that, we need to collect data over a longer period of time; data that will show whether restoration-related changes in habitat lead to changes in economic values.

Data on the economic value of ecosystem goods and services before and after a restoration can tell the analyst how value has changed after a restoration, but these data alone are insufficient to isolate the effect of the project from all other effects (e.g., changes in the price of travel, general avidity for a particular use like fishing, or changes caused by climate, weather, or other environmental conditions). Furthermore, data collected before and after a restoration often are not collected long enough before or after the event to allow for the realization of the full effects of the restoration. Data from too few years before restoration leave the analyst without a sound baseline for comparison. Data collected during or immediately after the restoration do not allow for the full ecological maturity of the restoration, and may not allow enough time for the change to affect the behavior of users (or values of non-users). For example, data collected one year before and after a salt marsh restoration would not necessarily capture the effects of the restoration on recreational uses or home values that depend on the maturity of the wetland.

To understand the complete economic effects of the restoration (the value of the restoration compared to what it would have been without the restoration) we need to control for other possible reasons that economic value may have changed. It may even be the case that restoration has caused the value of ecosystem services to remain constant while other factors were driving negative changes in these values. To better isolate the effects of restoration on the value of ecosystem goods and services the Panel recommends that ecological and economic data be collected well before and after the restoration and at locations with and without the restoration, including information on control sites (i.e., similar sites with no restoration or remediation projects). The length of time needed before or after and event will depend on the use and the type of restoration event examined. While the panel did not make any specific recommendations regarding the exact length of time, five years before and after an event would be reasonable, however, ongoing monitoring and data collection would be preferable.

The goal in collecting data with and without, and before and after restoration is to try to isolate the effects of restoration from other factors. A number of types of analysis can be used to analyze such data (referred to as time series cross-sectional data), but the basic model is:

$$Y_{it} = \text{constant}_i + \alpha \mathbf{X_{it}} + \beta \mathbf{Z}_{it} + \delta_{it}$$

Where **Y** is a measure of economic value at a site i and a time t. Y could be a direct measure of value (e.g., the price of a home near a restoration site, the price of a day of charter fishing, or an estimate of willingness to pay to access a site that was determined using other methods), it could be a measure of use or activity (e.g., the number of activity days at a site, for instance beach days, angler trips, visits by birdwatchers), or it could be a measure of an ecological attribute of known value (e.g., number of otters, fish abundance, or other ecological indicators). Note that value is the economic outcome we strive to measure. If the analyst uses activity or use as a measure, it is important to remember that the aggregated value (added up across all users) can change without a change in use or activity (e.g., the value per day changes, but the number of use days does not), the activity can change but the aggregated economic value does not, and the ecosystem can change but the total economic value may not change substantially (this depends on the availability of substitutes and also the total quality or amount of ecosystem good or service already available to the user).

X represents a specific type of restoration event that could occur at one or more sites. The restoration event could be measured as a 1/0 variable (a restoration of a certain type occurred =1, or not =0) or it could be one or more quantitative measures of the restoration (e.g., stream miles opened).

Z represents other explanatory factors (for instance per mile cost of travel, other economic factors or weather) that could explain the change in X, and α, β are coefficients that are estimated statistically. If the coefficient α is statistically different than zero, it means the relationship between the restoration event and the economic outcome X is not zero – in other words there is a relationship between restoration and the outcome. δ is the variation in the outcome that cannot be explained by the restoration event or the other explanatory variables.

As with all economic activities, many factors are at play in determining the use, use value, and non-use value of ecosystems. If this model were to be implemented, the Panel suggests that the analyst choose sites (i) for the analysis so that:

1) there are enough sites so that there is sufficient variation in X and Y so that the model can be estimated, and
2) as many unobserved factors as possible are held constant across sites and over time, and
3) some sites do not have restoration or remediation projects (i.e., control sites).

To try to decrease the need for many explanatory variables and to focus the analysis on similar (identical is the ideal) measures of economic outcome, the analyst first should choose sites that:

1) are as similar as possible in their basic ecosystem types, and
2) have similar uses or are valued for similar reasons across all sites

Statistical analysis requires variation in the variables analyzed. To ensure sufficient variation in ecological condition over time and sites, namely variation associated with restoration, the analyst should focus on sites that are likely to be restored over a certain course of time (say the next 5-20 years). This means there will be enough observations with and without, before and after, in the data.

Selection of studies sites is important. Using a quasi-experimental design (i.e., non-random selection of sites) will allow the analyst to statistically test for the effect of restoration or ecological change on the economic outcome (this is sometimes called the treatment effect). A non-random sample, however, cannot necessarily be used to generate a "value per habitat unit" measure that can be transferred to sites outside of the sample, especially if the sites were chosen because the analyst believed these were sites where restoration would have discernable effects. However, quasi-experimental designs do allow researchers to focus their sample to those sites that are comparable and have a control group, thus minimizing unexplained heterogeneity.

Also it is critical that there are clear and obvious ecological and behavioral relationships between Y, the outcome being measured, and X the restoration activity or change. The Panel recommends that the analyst choose a restoration theme (i.e. a type of restoration such as salt marsh restoration) for which there is a strong and well-documented relationship between restoration and value. For instance, the restoration of passage for recreationally important fish, the restoration of salt marsh in areas frequented by birdwatchers, the restoration of coral reefs that are used for recreational diving, the restoration of essential fish habitats that are demonstrably important for commercial harvest, the improvement of bacterial water quality for swimming areas, or the restoration of habitat essential for the presence of species with significant non-use values.

The analyst needs to be strategic in choosing when and where to measure outcomes. The goal is to estimate as accurately and precisely as possible the relationships between restoration activities and economic outcomes. Accuracy comes from a well-specified model and from controlling for as many confounding factors as possible. Precision comes from a having large samples. To do this, it is important to remember that the analyst:

1) does not need data from all sites in the region,
2) does not need measures of all components of Total Economic Value. Ideally, the analyst wants to focus on the values that are likely to be the most different because of restoration. (Note, if one value or use increases/decreases in value while another decreases/increases in value, then the analysis of only one outcome will not represent the overall change in value), and

3) does not need data from every day, month, or year (but the data do need to be collected in a consistent manner) as long as there is an obvious relationship between the measure of economic outcome and the measure of restoration activity.

Regardless of the economic outcomes, restoration outcomes, or explanatory variables chosen, it is critically important that the data for the analysis are consistent across time and across the sites examined. Without this consistency, measurement errors can be so large that it becomes difficult to accurately estimate the statistical relationship between the economic outcome and the restoration event.

5. A Proposed Methodology for Demonstrating the Economic Effects of Coastal Habitat Restoration Activities

The Panel spent much of its time providing suggestions about a more ambitious program to collect systematic data that would begin to reveal the effect of habitat restoration on economic outcomes. To date, there has been no systematic attempt to collect data to monitor any economic outcomes associated with coastal habitat restoration. There have been a number of large and costly restoration efforts including those in the Chesapeake Bay, San Francisco Bay, and Tampa Bay. Yet we have little concrete evidence about the economic effects of these restoration efforts. The Panel recommends that NOAA develop a strategic approach to pilot, test, and refine the collection of such data. Ultimately, the data needed to evaluate the economic outcomes of NOAA-led habitat restoration will also serve to monitor the effects of habitat restoration carried out by other agencies working within the same ecosystems. In fact, these data could serve to help monitor the economic outcomes of many types of ecological and environmental policies and changes in these ecosystems. While NOAA is taking a leading role in these efforts, the development of this work would benefit from a partnership of federal, state, local organizations and research institutions interested in habitat restoration and economic output.

In this section, we present a six-step approach to data collection that is derived from recommendations made by the Panel. The recommendations below could be implemented in whole or in parts, through a single effort or multiple smaller efforts.

Systematic, Project Level Data Collection

To build a programmatic valuation of the economic outcome of NOAA's habitat restoration efforts, the Panel made suggestions, which can be summarized in six basic steps for developing a Pilot Program. These steps are not necessarily sequential nor do all of them have to be completed in order to collect useful data.

STEP 1: CHOOSE A RESTORATION THEME

As described above, the Panel suggests that the agency consider focusing on restoration activities that are likely to have obvious effects on economic activity or value. Ideal candidates would meet one or more of the following criteria:

1) Large restoration events
2) Restoration events that affect a direct use
3) Restoration events that affect economically important species or habitat types

Specific examples of restoration themes that meet these criteria include dam removal (for fish passage restoration), large wetland restoration, dune restoration, and coral reef restoration.

STEP 2: CHOOSE A REGION

To minimize the need for many explanatory variables, the Panel recommends that the agency (and its partners) consider identifying a region where many similar restoration events are likely to occur. Examples include choosing Northern New England as a region to focus on fish passage restoration, Tampa Bay or San Francisco Bay as places to focus on salt marsh restoration, Hawaii or the Florida Keys as places to focus on coral reef restoration.

Focusing on a region will:

1) Help the analyst control for confounding factors (improves ease of analysis),
2) Allow the agency to start to develop an understanding of the cumulative, ecosystem level effects of restoration on economic outcomes. Many restoration activities have additive benefits for an ecosystem or region. The value of the whole may be greater than the sum of its parts due to

synergies within an ecosystem or region. Also, it is possible that the cumulative effect could be to create new substitutes within the region. For example, improving one salt marsh in an area may lower the extra benefit of restoring an additional salt marsh nearby. Focusing on one region will help start the process of determining the overall "regional" value of restoration.

STEP 3: CHOOSE SITES FOR DATA COLLECTION

The agency could identify sites where restoration is likely to occur and focus on data collection at these sites. For instance, if we examine dam removal in New England, NOAA and its partners do not need to collect data for uses at all rivers in New England or all rivers in New England with dams. Rather, they need to select sites with dams that may be candidates for removal; some of these sites will be removed (the treatments), some will not (the controls), thus giving us with and without, before and after data. If there are nearby sites that may serve as substitutes or complements for these sites, the agency also should consider including these sites in the analysis. The effect of restoration on an economic outcome may depend on activities and conditions at these other sites. The same principle would apply to the choice of wetland restoration.

If data are available from previous years, the analyst may be able to use data from past restoration events as well.

STEP 4: IDENTIFY THE METRICS AND DATA TO BE COLLECTED

Once the area, theme, and candidate projects have been identified, the agency will likely need to hire an interdisciplinary team of experts to identify data to be collected, including ecological indicators used, valuation methods used, and a monitoring plan.

A primary consideration in identifying data to be collected is a sound understanding of the factors that influence and thus help explain changes in an economic outcome. In some cases, such as angling, beach going, and home values, considerable empirical analysis exists in the literature to help understand the ecological, economic, and demographic factors that could help explain changes in these economic outcomes. In other cases, when the use or area is not well studied, onsite survey data will likely be required.

Focus groups, surveys (e.g., stated preference and revealed preference), and other onsite methods could be used to determine what uses/values/metrics will best capture the effects of dam removal in a way that can be easily collected. Several members of the Panel, however, noted that routine and repeated surveys may not be the best way to collect systematic data on economic outcomes because surveys can be expensive, and at least one panelist raised questions about the reliability (and comparability) of the surveys for meta-analysis.

The specific data that need to be collected will depend upon the restoration theme, the economic outcomes to be measured, and local data availability. For the sake of simplicity, assume dam removal is the theme and Northern New England is the region. In this case, the analyst may decide they want to examine two economic outcomes: effects on property values (e.g., real estate sales prices) and effects on recreational angling values. If recreational angling values are the focus, the analyst may decide to collect data on:

1) ECONOMIC OUTCOME DATA
   Angling trips made per year
   Willingness to pay for an angling trip
2) ECOLOGICAL RESTORATION DATA
   Stream miles restored
   Stream flow
   Fish abundance, diversity, and/or species present
3) OTHER EXPLANATORY DATA
   Stream characteristics that could change over time (especially due to restoration)
   Local weather
   Local economic factors (e.g., unemployment, fuel costs, parking or access fees)
   Accessibility

The exact choice of data to be collected will be determined by the analyst. Ideally, the Panel suggests that careful consideration be given to already existing data (e.g., park attendance or property value data).

These data need to be checked for consistency across time and sites. If data are too inconsistent, they may not be suitable. Existing data collection could potentially be modified to improve consistency in data collection across sites.

ONE OR MORE METRICS: While there may be value in collecting one iconic metric of economic outcome, a single measure of outcome will unlikely do a good job of capturing the many types of economic outcomes or even the most important outcomes that could result from coastal and estuary habitat restoration. The many restoration themes (e.g., fish passage, salt marsh, oyster reef, living shoreline, coral reef) and the many potential uses and values associated with these themes mean that each restoration theme will likely have a number of key economic values that should be measured and monitored.

It would be prudent on behalf of the agency and the analyst to collect a number of key measures of economic outcome for each region and theme, especially for the pilot project. For different types of restoration themes and values, the data needed (e.g., the number of observations) to statistically detect the effect of one or more restoration events will vary. By focusing on more than one economic outcome, the analyst will increase the likelihood of finding a statistically significant relationship between economic outcomes and restoration, if one exists.

STEP 5: START COLLECTING SYSTEMATIC DATA

Once the metrics and data are identified, the Panel suggests that systematic data collection begins as soon as possible at high-priority sites. The Panel noted the importance of ensuring that the data (economic, ecological, demographic, etc.) are rigorously collected in a manner that is consistent across time and sites, meaning that data are collected in a similar fashion at all sites and all times and that the methods are judged to be unbiased (or the bias must be well-understood).

STEP 6: SUPPLEMENTAL DATA

In addition to the systematic data collected at all target sites, the agency also should consider supplementing these data with on-site data that take advantage of specific restoration events. This supplemental data collection could include:

1) On-site surveys

When and where restoration is implemented, the agency could use the opportunity to conduct site-specific studies (travel cost, stated preference, etc.). Onsite data collection could focus on change in use (e.g., the number of visitor days) or change in value (the value per day). While the systematic data will be used to determine whether the restoration had a demonstrable effect on economic outcomes, the supplemental data will be important in demonstrating the "why and how" of this relationship. Additionally, several panelists recommended using supplemental data collection, including stated preference data, to show how restoration has influenced values not reflected by systematic monitoring data (e.g., non-market values, especially non-use values).

At least one panelist recommended that restoration-specific studies should allow for flexibility in approaches. In addition to providing supplemental data, the restoration-specific studies can provide the opportunity to explore new techniques for valuing restoration impacts. A lack of standardization in restoration-specific studies, however, will limit the application of any meta-analysis for these studies.

2) Better Ecological Monitoring Data

Currently, ecological data collected as part of restoration project monitoring are insufficient for benefit transfer (i.e., the ability to make inferences about values for sites with limited data from previously studied sites). Ecological data collected systematically should include, but not be limited to, attributes or ecological outcomes that are related to economic use or activity. Additionally, these ecological monitoring data will be more useful if they are similar to ecological attributes valued elsewhere in the literature. These data will provide the opportunity for the transfer of value estimates from other research sites. Finally, ecological monitoring data should meet the criteria detailed for economic data (e.g., consistent across time and sites, rigorously collected, the baseline data should be collected well before restoration and should continue well after restoration).

6. The Agency's Capacity for Conducting Data Collection and Analysis

Getting Restoration Partners and Grantees to Collect Better Data

In order to motivate restoration partners and grantees to participate in collecting systematic data for measuring and monitoring economic outcomes, the agency first needs to continue to demonstrate the potential economic benefits of restoration. As a first step, the Panel recommends that the agency begin by using the literature to demonstrate the general value of restoration projects. The Restoration Center could continue to build on its work with Restore America's Estuaries (e.g., The Economic and Market Value of America's Coasts and Estuaries) and other partners to provide resources for those interested in the economic benefits of restoration. Particularly, the Panel recommends a website that would provide more case studies and summaries of examples from peer-reviewed and gray literature. The website also could include links to relevant online resources like those below:

www.coastalvalues.org/work/resources.html
www.oceaneconomics.org/nonmarket/
marineeconomics.noaa.gov/bibsbt/welcome.html
www.evri.ca/
www.indecon.com/iec_web/menu/infoprod.asp
recvaluation.forestry.oregonstate.edu/home.html
www.fs.fed.us/rm/pubs/rmrs_gtr72.pdf
buvd.ucdavis.edu/
www.canri.nsw.gov.au/nrdd/records/ANZNS0281000027.html
www.beijer.kva.se/valuebase.htm
www.bfafh.de/DB_forestvalues.htm

Additionally, some on the Panel felt that the agency needs to develop specific guidance for grantees and those writing proposals about what economic outcomes and explanatory data can and should be collected and how these data ought to be collected. When appropriate, the agency could mandate that specific data are collected for restoration projects conducted within certain themes or areas. The agency also could provide, especially in “requests for proposals” and in funding guidelines, an indication of “priority areas” for the types of projects for which economic data are desired and the preferred methods for collecting data. At least one panelist, however, urged that grantees be given latitude in developing supplemental data collection approaches and methods for analysis.

Managing Data and Systematic Analysis

The success of systematic, long-term data collection depends on the existence of a long-term home for data collection, oversight, and routine analysis.

The data could be managed intramurally. NOAA could manage data collection directly and conduct routine assessments like those done through NMFS (e.g., tons of fish landed, etc.). This does not mean NOAA personnel need to collect data, but all systematic data would be submitted to NOAA. This would likely require more economic capacity at NOAA than exists currently.

Another approach would be to contract with a university partner or NGO to manage data collection and synthesis. Data in this type of extramural arrangement should be made available publicly in a timely manner. Extramural partnerships for data collection and management could be made with cooperating federal, state, and local partners. NOAA could work with Estuary Restoration Act Council members to coordinate data collection, especially among similar restoration efforts (within a restoration theme or area). Such a partnership would allow the agency to increase the number of sites monitored, share the burden of the cost of collection and analysis, and would help guarantee that common metrics for monitoring and analyzing economic outcomes are used across the different agencies. At the federal level, a partnership among the ERA Council members would meet the guidelines for inter-agency collaboration required by the proposed Principles and Guidelines for Water Resource Studies (CEQ, p13).

7. How Might Economic Monitoring Influence the Choice of Restoration Projects at NOAA and Elsewhere

There is a concern that the economic monitoring of existing or recently proposed restoration projects will not yield significant results. This is rooted in three core issues. First, many restoration projects are small and have only incremental effects on people or ecosystems. However, the cumulative effects may be larger and easier to measure than those of small restoration efforts. Second, many restoration projects are designed for non-economic social outcomes (e.g., community participation and education) that are not easily measured using economic methods. Third, many restoration projects are designed to improve ecosystem function and are not tied directly to human uses or values. Many indirect benefits of ecosystem function, such as nutrient cycling and water regulation, can be more difficult to measure and value than those directly tied to human uses.

While there are non-economic reasons for the selection and design of restoration projects, designing some restoration projects and programs to include economic outcomes and objectives in addition to ecological outcomes is likely to become increasingly important for the agency. Furthermore, restoration projects compete for funds with other projects – at the federal, state, and local levels – many of which yield easily measureable economic outcomes. Demonstrating that restoration projects have measureable economic outcomes and providing direct evidence of these outcomes will help these projects to compete in this regard.

NOAA can take steps to make sure that at least a subset of its restoration projects has measurable economic outcomes. The agency can begin to target community restoration proposals that contribute to a larger program of overall estuarine restoration (i.e. leverage the cumulative effects of many smaller restoration projects like those in Tampa Bay that contribute to the overall ecological and economic productivity and resiliency of the estuary). For purposes of this work, the agency could target large restoration projects (e.g., dams or large wetland restorations) and select more restoration projects that have clear economic benefits (e.g., wetland restoration in areas of high potential recreational use or located near homes). The agency also could begin to select restoration projects that have high value when combined with other policy actions (e.g., restoration projects near protected areas, shellfish beds, or waterways that will benefit from the reduced sedimentation provided by the restored wetland). Finally, the agency could select restoration projects that make beneficial use of sediments that sometimes are considered “spoils to be disposed off” (or oyster shells or other substrates).

8. Conclusion

The Blue Ribbon Panel found that the time is right to initiate the collection of long-term, systematic data to begin to measure and monitor the impact of restoration on economic outcomes.

During its meeting in December 2009, the Panel provided suggestions that we summarized as a six-step approach to commencing a program for the systematic collection of data on economic and ecological outcomes associated with coastal and estuary habitat restoration and explanatory factors needed to analyze these data. The approach is general and the details will depend ultimately on which of many types of habitat restoration the agency decides to monitor. The agency could also implement these suggestions by initiating more than one regional study. A pilot or demonstration project(s) could provide technical insight and guidance for future efforts that will be needed for the agency if systematic and long-term data will be collected

Key Recommendations from the Panel:

1) Start collecting systematic long-term data on ecological and economic outcomes, now.
2) Begin by selecting one or more restoration themes that have clear and demonstrable links to economic outcomes.
3) For each restoration theme selected, focus on a region for which this restoration theme is common.
4) Select sites for data collection where restoration is likely to occur and start collecting data as soon as possible.
5) Use on-site surveys and other site-specific data collection to identify economic and ecological data to be collected and to collect data that will supplement the longer-term, systematic data.
6) Once the approach and analysis are well established, extend data collection to other regions and restoration themes.
7) Make good examples of economic metrics and measures of economic outcomes available to restoration partners through a website.

Because systematic, long-term data collection has not been initiated for coastal and estuarine habitat restoration, the Panel envisioned this process as one in which the agency learns by doing. It is an approach similar to that followed historically in the attempt to constantly improve the collection and analysis of fisheries data. NOAA and its partners in the Estuary Restoration Act Council can be leaders in developing an understanding of the economic outcomes of coastal ecosystem change – an understanding that will benefit all aspects of coastal ecosystem management.

Restoration has the potential to be a valuable policy tool to achieve ecological and economic goals. While NOAA continues in its mission to restore ecologically critical habitat, it could benefit from working with the larger restoration community to also think about how to explicitly incorporate economic goals in the design and choice of restoration efforts. If the restoration community considers the explicit economic ramifications of its work and incorporates these concepts in its restoration framework, it will become increasingly easier to detect the economic effects of future restoration projects, choose economically efficient ones to implement, and demonstrate their economic outcomes.

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Appendix 1: Defining and Measuring Economic Values

From Holland, D.S., J. Sanchirico, R.J. Johnston and D. Joglekar. 2009. Economic Analysis for Ecosystem Based Management: Applications to Marine and Coastal Environments. Washington, DC: RFF Press. Reprinted with permission from the authors.

"Methods used to quantify relevant economic outcomes can sometimes be surprising to non-economists. For example, policymakers and the media often consider increases in employment (more jobs) to be an economic benefit. If modeled within an economic framework, however, employment increases are rarely considered an economic benefit of a project or policy. The reason is that if one consistently tracks both the benefits and costs associated with additional employment—and if the value of goods or services produced by newly employed individuals is measured appropriately elsewhere—then the benefits and costs of new employment wash out, leaving no additional net benefit of the created jobs. As a simple illustration, consider that the wages received by an employee (a benefit to the employee) are exactly offset by the wages paid by the employer (a cost to the employer). Although in reality the situation is somewhat more complex than this simple illustration, the common misperception that jobs are benefits illustrates that appropriate economic modeling does not always comport with common public understanding of what comprises an "economic" benefit or cost.

Similarly, policymakers will often request information—for example the "total" value of a very large ecosystem, such as the Chesapeake Bay—that is effectively meaningless from an economic perspective. Continuing the Chesapeake example, the nonsensical nature of "total" benefit measures relate to the lack of a consistent and meaningful baseline from which benefits or costs can be compared. Without a clear and detailed description of what it would mean to be "without" the Bay in its entirety—something impossible to envision or characterize with any validity—measures of total value remain devoid of meaning. This lack of meaning has not prevented the publication of myriad reports that attempt to quantify exactly these types of values. The guidelines that determine the appropriate quantification of economic outcomes—be they economic impacts, benefits, costs, or other measures—are designed to promote consistent, comparable, and meaningful measures across policies and projects. "

Appendix 2: An Annotated Bibliography of Research on Restoration Values

Acharya, G. (2000). Approaches to valuing the hidden hydrological services of wetland ecosystems. *Ecological Economics* 35(1): 63-74.

This paper investigates the role of the production function approach in capturing the value of hydrological services of wetland ecosystems. Hydrological research in the Hadejia-Nguru wetlands in northern Nigeria suggests that the major role of the wet season inundation of the wetlands is in recharging the underlying aquifers. This paper shows that the hydrological services extend beyond direct use values, and have a significant economic value associated with them. Whereas the direct benefits provided by the wetlands, such as floodplain agriculture, fishing and forestry, have previously been assessed, this paper synthesizes the results of two approaches to capture the value of indirect benefits derived from the role of the wetlands in replenishing and maintaining groundwater resources within the wetland area. (C) 2000 Elsevier Science B.V. All rights reserved.

Alvarez-Farizo, B., J. M. Gil, et al. (2009). Impacts from Restoration Strategies: Assessment through Valuation Workshops. *Ecological Economics* 68(3): 787-797.

Recent decades have seen a wide range of pollutant spills affecting natural, industrial, urban and rural areas (Exxon Valdez, Amoco Cadiz, Erika, Prestige, the Chernobyl nuclear power plant, and the Aznalcollar mines in Spain, to name a few). The extent of damage covers both time and space. Therefore, in order to mitigate the effects of pollution, it is necessary to adopt integrated management of both productive and natural areas. However, to be effective it is necessary to consider not only the health or biophysical effects of the countermeasures, but also the response of individuals to these changes. The purpose of this study is to assess the potential social and environmental impacts derived from the implementation of restoration strategies resulting from spills. Our approach is based on a choice experiment applied within the context of a citizens' valuation workshop or market stall in Cumbria (UK) and Zaragoza (Spain). The results highlight the advantages of this participatory technique versus traditional surveys.

Armand, C., F. Bonnieux, et al. (2002). An economic assessment of inland fisheries management schemes. *Bulletin Francais De La Peche Et De La Pisciculture* (365-66): 565-578.

In France, angling societies are, under the supervision of the government, generally in charge of inland fisheries management. The National Council of Fishing has developed a series of guidelines to design management schemes which favor natural reproduction processes and the preservation of wild fish stocks. They rely on habitat protection and ecosystem restoration programmes involving public expenditures whose profitability has to be assessed. This leads to estimate the value of wild fish (born in the natural environment from parents wild fish themselves). This value integrates two main components, a use value which is derived from angling and a non use value which stems from the existence of wild fish and concerns a broader population than the anglers one. Potential benefits stemming from the existence of wild fish populations are estimated using the contingent valuation method. Empirical results are based on a sample of 1 629 anglers who participated in a mail survey. Willingness-To-Pay (WTP) for wild fish increases with income, cost of equipment and trip distance. Other things being equal, those preferring fish such as pike and trout (reference species of the study), and those preferring to angle wild fish are likely to pay an additional amount. Mean WTP ranges from FF 50 to FF 100 per year, depending on model specification. This money amount is associated with the concept of total value which includes a use and a non use component. Some anglers are willing to pay but are not interested in fishing wild fish. For these people, WTP states a non use value and is associated with the existence of wild fish. The corresponding amount is estimated to be between FF 20 and FF 50. A straightforward calculation shows that anglers' potential benefits are of the same magnitude than the operating costs associated to management schemes.

Barbier, E. B. (2000). Valuing the environment as input: review of applications to mangrove-fishery linkages. *Ecological Economics 35*(1): 47-61.

The following paper reviews recent developments in the methodology for valuing the role of wetlands in supporting economic activity. The main focus will be on mangroves serving as a breeding ground and nursery habitat in support of coastal and marine fisheries. As this particular ecological function of a mangrove system means that it is effectively an unpriced 'environmental' input into fisheries, then it is possible to value this contribution through applying the production function approach. The first half of the paper overviews the procedure for valuing the environment as an input, applied to the case of a wetland supporting a fishery. Both the 'static' Ellis-Fisher-Freeman approach and the 'dynamic' approach developed by Barbier and Strand, incorporating the intertemporal bioeconomic fishing problem, are reviewed. The second half of the paper discusses briefly two recent case studies of mangrove-fishery valuation. An application in South Thailand, which is based on the static Ellis-Fisher-Freeman model, and an application in Campeche, Mexico, which is based on the dynamic approach.

Barbier, E. B. (2007). Valuing ecosystem services as productive inputs. *Economic Policy* (49): 178-229.

This paper explores two methods for valuing ecosystems by valuing the services that they yield to various categories of user and that are not directly valued in the market, and illustrates the usefulness of these methods with an application to the valuation of mangrove ecosystems in Thailand. The first method is known as the production function approach and relies on the fact that ecosystems may be inputs into the production of other goods or services that are themselves marketed, such as fisheries. I discuss issues that arise in measuring the input into fisheries, particularly those due to the fact that the fishery stock is changing over time, and the shadow value of the ecosystem consists in its contribution to the maintenance of the stock as well as its contribution to current output. The second method is known as the expected damage approach and is used to value the services of storm protection in terms of the reduction in expected future storm damage that the ecosystem can provide. These two methods are shown to yield very different valuations of ecosystems from those that would be derived by the methods typically used in cost-benefit analyses. I argue that they represent a significant improvement on current practice.

Barbier, E. B., I. Strand, *et al*. (2002). Do open access conditions affect the valuation of an externality? Estimating the welfare effects of mangrove-fishery linkages in Thailand. *Environmental & Resource Economics* 21(4): 343-367.

Mangroves are considered ecologically important due to their role as breeding grounds and nursery habitats for off-shore fisheries. However, mangrove deforestation through conversion to shrimp aquaculture threatens this valuable function. This paper develops a `dynamic' production function approach to analyze the influence of habitat changes on an open access fishery that faces a finite elasticity of demand. The basic model is applied to a case study of the impacts of mangrove deforestation on the artisanal marine demersal and shellfish fisheries in Thailand. By estimating parameters through pooled time-series and cross-sectional data over the 1983-1993 period for the five coastal zones of Southern Thailand, the welfare impacts of mangrove deforestation are estimated under different elasticity of demand assumptions. Under pure open access, the welfare losses estimated for mangrove deforestation in Thailand of 30 km (2) annually ranged from $12,000 to $408,000 depending on the elasticity of demand.

Bednarek, A. T. (2001). Undamming rivers: A review of the ecological impacts of dam removal. *Environmental Management* 27(6): 803-814.

Dam removal continues to garner attention as a potential river restoration tool. The increasing possibility of dam removal through the FERC relicensing process, as well as through federal and state agency actions, makes a critical examination of the ecological benefits and costs essential. This paper reviews the possible ecological impacts of dam removal using various case studies.

Restoration of an unregulated flow regime has resulted in increased biotic diversity through the enhancement of preferred spawning grounds or other habitat. By returning riverine conditions and sediment transport to formerly impounded areas, riffle/pool sequences, gravel, and cobble have reappeared, along with increases in biotic diversity. Fish passage has been another benefit of dam removal. However, the disappearance of the reservoir may also affect certain publicly desirable fisheries.

Short-term ecological impacts of dam removal include an increased sediment load that may cause suffocation and abrasion to various biota and habitats. However, several recorded dam removals have suggested that the increased sediment load caused by removal should be a short-term effect. Pre-removal studies for contaminated sediment may be effective at controlling toxic release problems.

Although monitoring and dam removal studies are limited, a continued examination of the possible ecological impacts is important for quantifying the resistance and resilience of aquatic ecosystems. Dam removal, although controversial, is an important alternative for river restoration.

Bell, F. W. (1997). The economic valuation of saltwater marsh supporting marine recreational fishing in the southeastern United States. *Ecological Economics* 21(3): 243-254.

This paper is concerned with placing an economic value on the contribution of wetlands in supporting recreational fishing in the southeastern United States. A production function first links the recreational catch to angler fishing effort and wetlands. The parameters of the recreational fisheries production function are estimated using cross-sectional data by states. To simplify the mathematics, the estimated elasticities are substituted into a Cobb-Douglas production function. For simplicity, a linear demand curve for recreational fishing is postulated which shifts when there is an increase or decrease in the catch (success rate). Therefore, incremental changes in wetlands will via the production function provide incremental changes in the catch which will in turn shift the recreational demand curve, thereby increasing or decreasing consumer surplus. Using a discount rate of 8.125%, the perpetual flow of consumer surplus per incremental acre of wetlands has an estimated asset value of $6,471 and $981 on the East and West Coast of Florida respectively in 1984 dollars. If commercial fisheries and other economically useful functions of wetlands are added to recreational fisheries, it may be more efficient for the State of Florida to acquire more coastal land for preservation from development.

Bergstrom, J. C., J. H. Dorfman, *et al*. (2004). Estuary management and recreational fishing benefits. *Coastal Management* 32(4): 417-432.

Recognition of the benefits to society supported by estuary ecosystem functions and services, and threats to these benefits posed by human activities, has led to various public programs to restore and protect estuaries at the federal, state, and local levels. As available budgets shrink, program administrators and public elected officials struggle to allocate limited restoration and protection funds to the highest priority areas. Economic benefit and cost information can provide useful inputs into this decision-making process by quantifying estuary restoration and protection benefits and costs in commensurate terms. In this paper, a combined actual and intended travel behavior model is described that can be applied to estimate the recreational fishing benefits of estuary restoration and protection. The model was estimated for recreational fishing in the Lower Atchafalaya River Basin estuary along the Gulf of Mexico, Louisiana, USA coast. Changes in freshwater flows into this estuary may affect redfish and speckled trout game fish populations. The model indicates that changes in catch rates of these two species would have a relatively minor affect on annual fishing trips per angler. However, because total effects may be large when effects per angler are aggregated across total anglers, resource management agencies should consider these changes in recreation benefits when evaluating projects that influence the ecology of coastal estuaries, fish populations, and catch rates.

Moreover, in other coastal areas or situations, the responsiveness of angling trips to changes in catch rates may vary because of differences in user populations, environmental conditions, fish populations, and fishing experiences.

Berman, M. and U. R. Sumaila (2006). Discounting, Amenity Values, and Marine Ecosystem Restoration. *Marine Resource Economics* 21(2): 211-219.

Colin Clark, during his wrap-up of the 2005 Biennial Forum of North American Fisheries Economists that took place at the University of British Columbia, Vancouver, Canada, challenged participants regarding discounting as a barrier to demonstrating the economic viability of ecosystem restoration. Through this contribution, we hope to initiate a conversation among marine resource economists on the role of discounting on ecosystem restoration and the long-term, sustainable management of marine resources. We relate the problem of discounting benefits of ecosystem restoration to that of valuing the amenities that restored ecosystems could produce, and suggest how empirical research might contribute to the debate over the proper discount rate to apply in valuing natural and ecosystem resources.

Bhat, M. G. (2003). Application of non-market valuation to the Florida Keys marine reserve management. *Journal of Environmental Management* 67(4): 315-325.

The quality of the coral reefs in the Florida Keys is essential to sustain nature-based tourism in the Keys. The recently established marine reserves (MR) are expected to improve the reef environment, particularly coral and fish abundance and diversity. In this paper, a combined model of travel cost and contingent behavior was estimated in order to measure the non-market recreational benefits of reef quality improvements. The results indicated that an average visitor would undertake 43-80% more number of trips to the Florida Keys and experience a 69% increase in the use values per trip, as a result of the MR-induced reef quality improvements. The above non-market value estimates were further applied to evaluating alternative management proposals for funding the MR program. It was found that the annual management costs of the MR program would constitute an insignificant portion-only around one to 2%-of the annual recreational benefits that the MR would generate. The results provide a strong economic justification for designing user-based funding mechanisms in order to make the MR program self-sustaining in the future. (C) 2002 Elsevier Science Ltd. All rights reserved.

Birol, E. and V. Cox (2007). Using Choice Experiments to Design Wetland Management Programmes: The Case of Severn Estuary Wetland, UK. *Journal of Environmental Planning and Management* 50(3): 363-380.

This paper reports the results of a pilot valuation study, which was undertaken to investigate whether the public located around the Severn Estuary derive positive economic values from its sustainable management. One hundred members of the public took part in a choice experiment, the results of which indicate that overall the public derives positive and significant values from sustainable management of this wetland;

however, there is some preference heterogeneity. The findings demonstrate that the choice experiment method is a promising tool, which can aid the design of socially optimal policies for sustainable management of the Severn Estuary, with possible implications for other similar wetlands in the UK.

Boyer, T. and S. Polasky (2004). Valuing urban wetlands: A review of non-market valuation studies. *Wetlands* 24(4): 744-755.

Wetlands provide a range of valuable ecosystem services from water purification and nutrient retention to recreation and aesthetics. The value of these services is often difficult to quantify and document to policy makers and the general public. Economists have developed non-market approaches to address difficult issues related to valuation of the environment. This paper reviews recent literature on non-market valuation as applied to wetlands, with a particular focus on the value of urban wetlands. Wetland valuation studies have generated a wide range of values, in part due to differences in what is valued and in part due to differences in methodology. Several studies have shown that property owners value proximity to wetlands in urban areas. In addition, studies have found positive values for recreation (fishing and hunting), commercial fishing, water purification, and other ecosystem services provided by wetlands, although little of this work has been done on urban wetlands. Valuation studies can provide useful information about relative rankings of value, showing, for example, that certain types of wetlands or certain services are more highly valued than others. Whether the absolute magnitude of valuation estimates is correct is less clear.

Brander, L. M., R. Florax, *et al.* (2006). The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature. *Environmental & Resource Economics* 33(2): 223-250.

Wetlands are highly productive ecosystems, providing a number of goods and services that are of value to people. The open-access nature and the public-good characteristics of wetlands often result in these regions being undervalued in decisions relating to their use and conservation. There is now a substantial literature on wetland valuation, including two meta-analyses that examine subsets of the available wetland valuation literature. We collected over 190 wetland valuation studies, providing 215 value observations, in order to present a more comprehensive meta-analysis of the valuation literature that includes tropical wetlands (e.g.,, mangroves), estimates from diverse valuation methodologies, and a broader range of wetland services (e.g.,, biodiversity value). We also aim for a more comprehensive geographical coverage. We find that socio-economic variables, such as income and population density, that are often omitted from such analyses are important in explaining wetland value. We also assess the prospects for using this analysis for out-of-sample value transfer, and find average transfer errors of 74%, with just under one-fifth of the transfers showing errors of 10% or less.

Brander, L. M., P. Van Beukering, *et al.* (2007). The recreational value of coral reefs: A meta-analysis. *Ecological Economics* 63(1): 209-218.

Coral reefs are highly productive ecosystems that provide a variety of valuable goods and services, including recreational opportunities. The open-access nature and public good characteristics of coral reefs often result in them being undervalued in decision making related to their use and conservation. In response to this, there now exists a substantial economic valuation literature on coral reefs. For the purposes of conducting a meta-analysis of this literature, we collected 166 coral reef valuation studies, 52 of which provided sufficient information for a statistical meta-analysis, yielding 100 separate value observations in total. Focusing on recreational values, we use US$ per visit as the dependent variable in our meta-analysis. The meta-regression results reveal a number of important factors in explaining variation in coral reef recreational values, notably the area of dive sites and the number of visitors. Different valuation methods are shown to produce widely different values, with the contingent valuation method producing significantly lower value estimates. Using a multilevel modeling approach we also control for authorship effects, which proves to be highly significant in explaining variation in value estimates. We assess the prospects for using this analysis for out-of-sample value transfer, and find average transfer errors of 186%. We conclude that there is a need for further high-quality valuation research on coral reefs.

Brouwer, R., I. H. Langford, I. J. Bateman and R. K. Turner (1999). A meta-analysis of wetland contingent valuation studies. *Regional Environmental Change* 1(1).

There is growing interest in the potential for producing generally applicable models for valuing non-market environmental services which do not rely upon expensive and time-consuming survey work, but rather extrapolate results from previous studies. This paper presents a meta-analysis for the use and non-use values generated by wetlands across North America and Europe. The study assesses the socio-economic values attributable to the hydrological, biogeochemical and ecological functions provided by such complex environmental assets. The clustering of multiple values derived from single studies is examined through the application of multilevel modelling methods allowing for the hierarchical structure of such data.

Burger, J. (2003). Perceptions about Environmental Use and Future Restoration of an Urban Estuary. *Journal of Environmental Planning and Management* 46(3): 399-416.

Recent interest in restoring urban ecosystems has engendered studies on public perceptions of these ecosystems and future land use. This paper examines the perceptions of people using the waterfront area of the New York/New Jersey harbor estuary about their use of the area, and how this environment could be improved. Pollution was viewed as the most important problem in New Jersey, and removing pollution was rated the most important way to improve the waterfront habitat. Using the remaining undeveloped area for natural habitat and to improve quality of life were rated as the most important uses of the waterfront. People valued the waterfront for walking, providing open green space, and as a place to commune with nature without people. Management options people favored were removing pollution and cleaning up rubbish and adding educational signs and information brochures about the remaining, natural habitat. Age, income and education influenced which activities people said they undertook. For improvements to the waterfront: Hispanics rated adding educational signs and creating information brochures higher, Blacks rated building promenades as more important, and Asians and Whites rated improving habitat for birds and butterflies more important than others. The data indicate that the public has a firm understanding of the big picture (pollution in the region and locally), habitat improvement, and of the small improvements that can be done locally. Planners and managers could move forward on three fronts: source reduction, wildlife habitat improvement, and amenity (signs, brochures, cleaning up rubbish) development. Understanding how people use an environment, and wish to improve it, can provide valuable information for future restoration and management of urban environments generally, as well as for structuring a citizen advisory committee.

Butler, J. R. A., A. Radford, *et al*. (2009). Evaluating an ecosystem service provided by Atlantic salmon, sea trout and other fish species in the River Spey, Scotland: The economic impact of recreational rod fisheries. *Fisheries Research* 96(2-3): 259-266.

In 2003 a study Was undertaken in the River Spey catchment, north-east Scotland, to estimate the economic impact of recreational rod fisheries for Atlantic salmon (Salmo salar), brown and sea trout (S. trutta), pike (Esox lucius), and non-native rainbow trout (Oncorhynchus mykiss). Thirty-one fishery owners and 372 anglers completed questionnaire surveys on average catches and angler effort in 1998-2002. Anglers reported their daily expenditure, and the CogentSI model was used to derive multiplier effects. Total annual angler days were 54,746, of which 74% were from salmon and sea trout anglers. Angler expenditure was estimated to be 11.8 pound million annum (-1), of which 10.8 pound million was generated by salmon and sea trout anglers. Accounting for multiplier effects, fisheries contributed 12.6 pound million annum (-1) to household incomes and 420 full time equivalent (FTE) jobs in the catchment. Of this, salmon and sea trout fisheries contributed 11.6 pound million annum-(1) and 401 FTEs. On average rod caught salmon and sea trout contributed approximately 970 pound fish (-1) to household incomes, equating to 26 pound smolt (-1) and 1 pound m (2) annum (-1) for riverine nursery habitat. The capital value of the salmon and sea trout rod fishery was 56.7 pound million. Comparison with a national survey of angler expenditure in 2003 suggests that the relative impact of salmon and sea trout in the Spey catchment's economy is one of the highest in the country. The application of angler expenditure as an evaluation of utilitarian ecosystem services provided by fish species and freshwater habitat is discussed. Crown Copyright (C) 2008 Published by Elsevier B.V. All rights reserved.

Chen, Z. M., G. Q. Chen, *et al*. (2009). Net ecosystem services value of wetland: Environmental economic account. *Communications in Nonlinear Science and Numerical Simulation* 14(6): 2837-2843.

For decision making in terms of environmental economics for wetland construction, restoration and preservation, net ecosystem services values of constructed, human-interfered and natural wetlands are explored in the present work as a comparative Study. The ecosystem services Values of a pilot constructed wetland in Beijing, China in different discount rates and time horizons are accounted and compared with those of the natural wetlands all over the world as a mean and of a typical human-interfered wetland in Wenzhou, China. Results show that in both finite and infinite time horizons considered, the constructed wetland has the largest net services value in a reasonable discount rate. (C) 2008 Elsevier B.V. All rights reserved.

Collins, A. R., R.S. Rosenberger, J. Fletcher (2005). The Economic Value of Stream Restoration. *Water Resources Research* 41.

The economic value of restoring Deckers Creek in Monongalia and Preston counties of West Virginia was determined from mail, Internet, and personal contact surveys. Multi-attribute, choice experiments were conducted and nested logit models were estimated to derive the economic values of full restoration for three attributes of this creek: aquatic life, swimming, and scenic quality. Their relative economic values were that aquatic life > scenic quality ≈ swimming. These economic values imply that respondents had the highest value for aquatic life when fully restoring Deckers Creek to a sustainable fishery rather than a “put and take” fishery that cannot sustain fish populations. The welfare improvement estimates for full restoration of all three attributes ranged between $12 and $16 per month per household. Potential stream users (anglers) had the largest welfare gain from restoration, while nonangler respondents had the lowest. When these estimates were aggregated up to the entire watershed population, the benefit from restoration of Deckers Creek was estimated to be about $1.9 million annually. This benefit does not account for any economic values from partial stream restoration. On the basis of log likelihood tests of the nested logit models, two subsamples of the survey population (the general population and stream users) were found to be from the same population. Thus restoration choices by stream users may be representative of the watershed population, although the sample size of stream users was small in this research.

Collins, A. R., R.S. Rosenberger (2007). Protest Adjustments in the Valuation of Watershed Restoration Using Payment Card Data. *Agricultural and Resource Economics Review* 36(2): 321-335.

When using a willingness-to-pay (WTP) format in contingent valuation (CV) to value water-shed restoration, respondents may protest by questioning why they should pay to clean up a pollution problem that someone else created. Using a sample selection interval data model based on Bhat (1994) and Brox, Kumar, and Stollery (2003), we found that the decision to protest and WTP values were correlated. Protest sample selection bias resulted in a 300 percent overestimate of mean WTP per respondent. Using different ad hoc treatments of protesters, protest bias resulted in moderate effects (-10 percent to +14 percent) after controlling for sample selection bias.

Connelly, N. A., B. A. Knuth, *et al*. (2002). Public support for ecosystem restoration in the Hudson River Valley, USA. *Environmental Management* 29(4): 467-476.

We applied the Theory of Planned Behavior to help understand the relationships between environmental beliefs, support for ecosystem restoration actions, and willingness to pay (WTP) for restoration and protection goals in the Hudson River estuary, New York State, USA. We conducted a mail survey with 3,000 randomly-chosen local residents of the Hudson River estuary in the fall of 1999. As hypothesized, the broad ecosystem restoration goals of the Hudson River Estuary Action Plan were more strongly supported than the corresponding specific implementation actions. We found that beliefs and past behavior were better explanatory variables than sociodemographic characteristics for explaining people's support for ecosystem restoration actions and WTP for restoration and protection goals. Because ecosystem restoration goals appear to be more generally acceptable than specific restoration actions, proponents of restoration programs should not become complacent about the need for active public outreach and involvement even if initial restoration program discussions have been low in controversy. Efforts to assess and foster support for ecosystem restoration should be targeted toward audiences identified on the basis of beliefs and past behaviors rather than on sociodemographic characteristics.

Dodds, W. K., K. C. Wilson, *et al.* (2008). Comparing Ecosystem Goods and Services Provided by Restored and Native Lands. *Bioscience* 58(9): 837-845.

We determined the relative benefits for eight categories of ecosystem goods and services associated with native and restored lands across the conterminous United States. Less than 10% of most native US ecosystems remain, and the proportion that is restored varies widely by biome. Restored lands offer 31% to 93% of native land benefits within a decade after restoration, with restored wetlands providing the most economic value and deserts providing the least. Restored ecosystems that recover rapidly and produce valuable commodities return a higher proportion of total value. The relative values of the benefits provided by restoration vary both by biome and by the ecosystem goods and services of interest. Our analysis confirms that conservation should be the first priority, but that restoration programs across geographic regions can have substantial value. "No net loss" policies should recognize that restored lands are not necessarily equivalent to native areas with regard to estimated ecosystem benefits.

Dunford, R. W., T. C. Ginn, *et al*. (2004). The use of habitat equivalency analysis in natural resource damage assessments. *Ecological Economics* 48(1): 49-70.

Federal and state government agencies and Indian tribes, acting on behalf of the public as trustees, can recover damages to natural resources from companies responsible for oil spills or hazardous-substance releases. Habitat equivalency analysis

(HEA) is a method for estimating the appropriate amount of compensation for interim losses resulting from such spills or releases. HEA has several restrictive assumptions that are not met in many situations and its input parameters often are not known with certainty, which can lead to substantial differences between HEA results and the "true" amount of compensation for losses resulting from oil spills or hazardous-substance releases. Critical assumptions of HEA include a preference for compensation with the same services as were injured, a fixed proportion of habitat services to habitat value, and a constant real value of services over time. HEA also requires that complex ecological services are expressed as a single metric and that the incremental effect of spills/releases are estimated reliably over time. Notwithstanding these important assumptions and limitations, HEA is frequently used to settle natural resource damage (NRD) claims and two HEA applications to NRD claims have been upheld by the courts. When properly structured and applied, HEA can produce relatively reliable results for most oil spills and simple cases involving hazardous-substance releases. Even when unmet assumptions and/or differences in professional judgment with respect to input parameters produce differences in HEA results, the method can be useful in achieving an NRD settlement in a variety of situations. However, HEA should only be viewed as a framework to provide a general approximation of any required restoration, and not as a substitute for a formal NRD assessment in cases involving complex hazardous-substance releases.

Gregory, R. and K. Wellman (2001). Bringing Stakeholder Values into Environmental Policy Choices: A Community-Based Estuary Case Study. *Ecological Economics* 39(1): 37-52.

This paper discusses a methodology for joining deliberation and analysis, using the case-study example of a National Estuary Program planning effort in Tillamook Bay, OR, USA. We describe the development of a community-based evaluation tool that links actions proposed by technical experts (e.g., biologists, ecologists, engineers) to restore functioning of the Tillamook Bay estuary with the values and concerns expressed by community residents. This task required the explicit consideration of trade-offs across multiple benefits, costs, and risks. We describe the design and results of an evaluation workbook, developed with input from both the EPA staff and community residents, that provided insight to decision makers by presenting participants with explicit choices across the key dimensions and consequences of proposed actions. The final section of the paper discusses the successes and limitations of the project in relation to evaluation needs associated with other environmental policy initiatives.

Gurluk, S. and E. Rehber (2008). A travel cost study to estimate recreational value for a bird refuge at Lake Manyas, Turkey. *Journal of Environmental Management* 88(4): 1350-1360.

This paper investigates the recreational economic value of bird watching in the Kuscenneti National Park (KNP) at Lake Manyas, one of the Ramsar sites of Turkey and an important endangered species habitat. The lake and KNP provide considerable benefits for the region although they have faced many environmental conflicts due to diverse stakeholders needs. An economic valuation for the benefits provided by the KNP is important data for stakeholders and local authorities. The travel cost method is used to estimate recreational demand for the KNP. The recreational value of the KNP is 103,320,074 USD annually. Results shed light on important policy issues and help to resolve conflicts among stakeholders. This calculated value is considerably higher than the annual investment and operation expenditures of the KNP. Sustainability of the important species around the lake could be achieved if the region's inhabitants are compensated by KNP visitors.

Gutrich, J. J. and F. J. Hitzhusen (2004). Assessing the Substitutability of Mitigation Wetlands for Natural Sites: Estimating Restoration Lag Costs of Wetland Mitigation. *Ecological Economics* 48(4): 409-424.

The extent and rate to which mitigation wetlands can replace the functions of natural ones remains uncertain. Further, the economic time lag costs of wetland function restoration and therefore cost-effective and efficient means of wetland mitigation have yet to be adequately addressed. In this study, 16 mitigation wetlands were assessed, comprised of eight low elevation inland freshwater emergent marshes in Ohio and eight high elevation (>2285 m) freshwater emergent marshes in a wetland complex in Colorado, USA. This research identified the ecological substitutability of mitigation inland freshwater marshes for natural ones, estimated economic restoration lag costs to society and addressed least-cost approaches to successful mitigation. Years required to achieve full functional equivalency for both floristics and soils for the Ohio sites under logarithmic growth ranged from 8 to 50 years with a median of 33 years. Years required to achieve floristic functional equivalency for the Colorado sites ranged from 10 to 16 years with a median of 13 years. Restoration lag costs per acre (0.4 ha) in Ohio ranged from $3460 to $49,811 per acre with an average of $16,640 per acre (2000 US$). Lag costs as a percentage of total restoration costs ranged from 5.6% to 52.8% with an average of 25%. Restoration lag costs per acre to achieve full floristic equivalency in Colorado ranged from $22,368 to $31,511 per acre with an average $27,392 per acre. Time lag costs as a percentage of total restoration costs ranged from 44% to 53% with an average of 49%. Findings of this research suggest that society is currently incurring significant wetland restoration costs due to time lags of mitigation sites. Requiring the posting of an interest accruing performance bond can serve to internalize the time lag costs to the permittee and provide an incentive for more cost-effective wetland restoration efforts.

Hein, L., K. van Koppen, *et al.* (2006). Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological Economics* 57: 209-228.

Since the late 1960s, the valuation of ecosystem services has received ample attention in scientific literature. However, to date, there has been relatively little elaboration of the various spatial and temporal scales at which ecosystem services are supplied. This paper analyzes the *spatial* scales of ecosystem services, and it examines how stakeholders at different spatial scales attach different values to ecosystem services. The paper first establishes an enhanced framework for the valuation of ecosystem services, with specific attention for stakeholders. The framework includes a procedure to assess the value of regulation services that avoids double counting of these services. Subsequently, the paper analyses the spatial scales of ecosystem services: the ecological scales at which ecosystem services are generated, and the institutional scales at which stakeholders benefit from ecosystem services. On the basis of the proposed valuation framework, we value four selected ecosystem services supplied by the De Wieden wetlands in The Netherlands, and we analyze how these services accrue to stakeholders at different institutional scales. These services are the provision of reed for cutting, the provision of fish, recreation, and nature conservation. In the De Wieden wetland, reed cutting and fisheries are only important at the municipal scale, recreation is most relevant at the municipal and provincial scale, and nature conservation is important in particular at the national and international level. Our analysis shows that stakeholders at different spatial scales can have very different interests in ecosystem services, and we argue that it is highly important to consider the scales of ecosystem services when valuation of services is applied to support the formulation or implementation of ecosystem management plans.

Hicks, C. C., T. R. McClanahan, *et al*. (2009). Trade-Offs in Values Assigned to Ecological Goods and Services Associated with Different Coral Reef Management Strategies. *Ecology and Society* 14(1).

Societies value ecosystems and the services they provide in a number of ways. These values can help inform the management of ecosystems such as coral reefs. However, the trade-offs in ecosystem goods and services associated with different social and management conditions are poorly understood. Consequently, we examined values assigned to the goods and services identified across three types of management on the Kenyan coast: (1) a government-imposed no-take area in the Mombasa Marine National Park; (2) co-management of gear between fishing communities and the government's fisheries department; and (3) community-initiated no-take area management, where a community independently initiated and controlled a small closed area. We compared the ecosystem goods and services and the broader total economic value to explore how the history of these sites, their social conditions, and different management choices were associated with these values. The highest total economic values were associated with government management interventions and were probably due to the government's priority to be involved in the high-value beach tourism destinations. This is, however, associated with losses in a range of local community-level values and the social capital of the resource-user community. For example, resource users near the government marine protected area had the lowest value for measures of biological knowledge. Sites displaying greater community-level values were characterized by high social capital, and users had the most confidence in their ability to manage the resource. This study suggests that trade-offs occur in values associated with the interests and responsibilities of the management. The ability to cope with disturbance and change will depend on these values and responsibilities, and local communities are less likely to respond when government management and interests are strong.

Holmes, T. P., J. C. Bergstrom, *et al*. (2004). Contingent Valuation, Net Marginal Benefits, and the Scale of Riparian Ecosystem Restoration. *Ecological Economics* 49(1): 19-30.

A study was undertaken to estimate the benefits and costs of riparian restoration projects along the Little Tennessee River in western North Carolina. Restoration benefits were described in terms of five indicators of ecosystem services: abundance of game fish, water clarity, wildlife habitat, allowable water uses, and ecosystem naturalness. A sequence of dichotomous choice contingent valuation questions were presented to local residents to assess household willingness to pay increased county sales taxes for differing amounts of riparian restoration. Results showed that the benefits of ecosystem restoration were a non-linear function of restoration scale and the benefits of full restoration were super-additive. We estimated the costs of riparian restoration activities by collecting and analyzing data from 35 projects in the study area. After adjusting our estimated valuation function for socio-economic characteristics of the local population, the benefit/cost ratio for riparian restoration ranged from 4.03 (for 2 miles of restoration) to 15.65 (for 6 miles of restoration). Riparian restoration in this watershed is therefore an economically feasible investment of public funds at all measured spatial scales.

Hosking, S. G. and M. du Preez (2004). A Recreational Valuation of the Freshwater Inflows into the Keurbooms Estuary by Means of a Contingent Valuation Study. *South African Journal of Economic and Management Sciences*, N.S. 7(2): 280-298.

This paper reports on a contingent valuation made of the freshwater inflow into the Keurbooms Estuary near Plettenberg Bay, South Africa, in April 2001. The value of this water was estimated in terms of the services yielded to recreation users of the estuary, to be between R0,012/m3 and R0,046/m3. This value is currently lower than what farmers are willing to pay for the water in this area, as measured by the income capitalization method, namely R0,125/m3, but may increase in the future as more and more South African estuaries are undermined through upstream river water abstraction, and recreational substitutes are diminished. A willingness-to-pay function was also estimated and show annual levies paid and investment in goods to access the estuary services to be important determinants of willingness-to-pay.

Ingraham, M. W. and S. G. Foster (2008). The value of ecosystem services provided by the US National Wildlife Refuge System in the contiguous US. *Ecological Economics* 67(4): 608-618.

Studies that demonstrate the economic value of the ecosystem services provided by public conservation lands can contribute to a more accurate appraisal of the benefit of these lands. The objective of this study was to estimate the economic value, in real (2004) dollars, of the ecosystem services provided by the U.S. National Wildlife Refuge System (Refuge System) in the contiguous U.S. In order to estimate this value, we determined the ecosystems present on the Refuge System in the contiguous 48 states, the proportion in which they are represented, and the dollar value of services provided by each. We used land cover classes as an approximation of ecosystems present in the Refuge System. In a geographic information system (GIS), we combined land cover geospatial data with a map of the Refuge System boundaries to calculate the number of acres for each refuge and land cover class within the Refuge System. We transfer-red values for the following ecosystem services: climate and atmospheric gas regulation; disturbance prevention; freshwater regulation and supply; waste assimilation and nutrient regulation; and habitat provision. We conducted a central tendency value transfer by transferring averaged values taken from primarily original site studies to the Refuge System based on the ecoregion in which each study site and refuge was located and the ecoregion's relative net primary productivity (NPP). NPP is a parameter used to quantify the net carbon absorption rate by living plants, and has been shown to be correlated with spatially fungible ecosystem services. The methodologies used in the site studies included direct market valuation, indirect market valuation and contingent valuation. We estimated the total value of ecosystem services provided by the Refuge System in the contiguous U.S. to be approximately $26.9 billion/year. This estimate is a first cut attempt to demonstrate that the value of the Refuge System likely exceeds the value derived purely from recreational activities. Due to limitations of current understanding, methods and data, there is a potentially large margin of error associated with the estimate.

Janssen, R. and J. E. Padilla (1999). Preservation or conversion? Valuation and evaluation of a mangrove forest in the Philippines. *Environmental & Resource Economics* 14(3): 297-331.

Mangrove ecosystems are rapidly declining in many parts of the world. This has resulted in the loss of important environmental and economic products and services including forest products, flood mitigation and nursery grounds for fish. The aquaculture industry was the single biggest threat to mangroves in the Philippines until 1981 when conversion of the remaining mangrove stands was prohibited by law. However, the decreasing yield from capture fisheries is putting pressure for the re-examination of this policy. To understand the importance of mangroves, insight is needed into the value of products and services provided is needed. This article compares the costs and benefits of mangrove preservation with those generated by alternative uses such as aquaculture and forestry. Equity and sustainability objectives are taken into account, in addition to economic efficiency and analyzed according to the perspectives of the different types of decision makers involved.

Johnston, R. J. and *et al.* (2002). Combining Economic and Ecological Indicators to Prioritize Salt Marsh Restoration Actions. *American Journal of Agricultural Economics* 84(5): 1362-1370.

No abstract available

Johnston, R. J., T. A. Grigalunas, *et al*. (2002). Valuing estuarine resource services using economic and ecological models: the Peconic Estuary System study. *Coastal Management* 30(1): 47-65.

This article summarizes four integrated economic studies undertaken to contribute to resource preservation and restoration decisions for the Peconic Estuary System of Suffolk County, NY. Completed as part of the National Estuary Program, the studies apply distinct resource valuation methods to a wide range of resource issues. The principal goals of this article are to highlight different methodologies that may be used to assess nonmarket economic values in a coastal management context, and characterize differences in the results that one may expect from each approach. We also emphasize potential relationships among values estimated by different nonmarket methodologies, and comment on the implications of these relationships for the interpretation and use of economic value estimates.

Kidd, S. (1995). Planning for Estuary Resources: The Mersey Estuary Management Plan. *Journal of Environmental Planning and Management* 38(3): 435-442.

Management plans are in preparation for many of England's estuaries. The paper outlines the background to the Mersey Estuary Plan, discusses its style and format, explains its approach to estuary resource issues and outlines policy responses in the areas of estuary dynamics, water quality, and pollution control, biodiversity, and land use and development. The paper concludes by drawing lessons which may be of relevance elsewhere.

Knowler, D. J., B. W. MacGregor, *et al*. (2003). Valuing freshwater salmon habitat on the west coast of Canada. *Journal of Environmental Management* 69(3): 261-273.

Changes in land use can potentially reduce the quality of fish habitat and affect the economic value of commercial and sport fisheries that rely on the affected stocks. Parks and protected areas that restrict land-use activities provide benefits, such as ecosystem services, in addition to recreation and preservation of wildlife. Placing values on these other benefits of protected areas poses a major challenge for land-use planning. In this paper, we present a framework for valuing benefits for fisheries from protecting areas from degradation, using the example of the Strait of Georgia Coho salmon fishery in southern British Columbia, Canada. Our study improves upon previous methods used to value fish habitat in two major respects. First, we use a bioeconomic model of the Coho fishery to derive estimates of value that are consistent with economic theory. Second, we estimate the value of changing the quality of fish habitat by using empirical analyses to link fish population dynamics with indices of land use in surrounding watersheds. In our example, we estimated that the value of protecting habitat ecosystem services is C$0.93 to C$2.63 per ha of drainage basin or about C$1322 to C$7010 per km of salmon stream length (C$1.00 = US$0.71). Sensitivity analyses suggest that these values are relatively robust to different assumptions, and if anything, are likely to be minimum estimates. Thus, when comparing alternative uses of land, managers should consider ecosystem services from maintaining habitat for productive

fish populations along with other benefits of protected areas.

Kosz, M. (1996). Valuing riverside wetlands: The case of the ''Donau-Auen'' national park. *Ecological Economics* 16(2): 109-127.

For two decades, the establishment of the ''Donau-Auen'' national park east of Vienna has been on the political agenda in Austria. Since 1991, concrete proposals have been worked out for several variants of a national park including hydraulic engineering concepts and hydroelectric power stations. Within this planning process a cost-benefit analysis was carried out to estimate the economic impacts of the proposed projects. One crucial question was how to value the ecological quality of wetlands, These environmental goods were valued by means of a willingness-to-pay (WTP) survey, Two different kinds of variables were defined: (1) Costs and benefits depending on direct ''anthropocentric'' use including energy production with hydroelectric power stations, shipping, groundwater protection, stabilization of the river bed to stop channel erosion, visitors' benefits, forestry, farming, fishing, hunting and the costs of establishing a national park, Based on these variables the net present value for variants with hydroelectric power stations is higher than for variants without electricity production. On the contrary, the internal interest rate and the benefit-cost ratio is higher for a ''pure'' national park without electricity production. (2) Taking also the Austrians' WTP for the ''Donau-Auen'' national park as a substitute measure for ecological values into account, only 20 percent of the WTP which was measured by means of contingent valuation is needed to make the net present value of the ''best'' national park variant equal to that of the ''best'' hydroelectric power variant, This shows that the protection of natural goods, like wetlands, in a natural state might be more efficient from an economic viewpoint than development projects.

Kragt, M. E., P. C. Roebeling, *et al*. (2009). Effects of Great Barrier Reef degradation on recreational reef-trip demand: a contingent behavior approach. *Australian Journal of Agricultural and Resource Economics* 53(2): 213-229.

There is a growing concern that increased nutrient and sediment runoff from river catchments are a potential source of coral reef degradation. Degradation of reefs may affect the number of tourists visiting the reef and, consequently, the economic sectors that rely on healthy reefs for their income generation. This study uses a contingent behavior approach to estimate the effect of reef degradation on demand for recreational dive and snorkel trips, for a case study of the Great Barrier Reef in Australia. Results from a negative binomial random effects panel model show that the consumer surplus current reef visitors derive from a diving or snorkeling trip is approximately A$185 per trip. Furthermore, results indicate that reef trips by divers and snorkelers could go down by as much as 80 per cent given a hypothetical decrease in coral and fish biodiversity. This corresponds to a decrease in tourism expenditure by divers and snorkelers on full-day reef trips in the Cairns management area of the Great Barrier Reef Marine Park of about A$103 million per year.

Lewis, L. Y., C. Bohlen, *et al*. (2008). Dams, Dam Removal, and River Restoration: A Hedonic Property Value Analysis. *Contemporary Economic Policy* 26(2): 175-186.

This article presents the results of a hedonic property value analysis for multiple hydropower sites along the Kennebec River in Maine, including the former site of the Edwards Dam in Augusta, Maine. The effect of the removal of the Edwards Dam on the Kennebec River in Maine is examined through consumer's marginal willingness to pay to be close to or distant from the dam site. Data from both before and after the dam was removed are used to estimate changes in marginal prices. A similar data set is also used to look at the effects of the remaining upstream dams on property values. This article presents one of the first (to our knowledge) ex post analyses on the economic impact of dam removal on property values. As more privately owned dams in the United States come up for relicensing, evaluating the impacts with and without the dam will become increasingly important. This work can help inform those analyses.

Lipton, D. W. and I. E. Strand (1997). Economic effects of pollution in fish habitats. *Transactions of the American Fisheries Society* 126(3): 514-518.

Pollution in fish habitats can have economic effects on three groups: (1) commercial users and consumers; (2) recreationalists; and (3) nonusers. In commercial fisheries, the economic costs of pollution in the fishery habitats derive from lower production, or consumer perception of reduced fish quality, or both. The economic loss will depend on many factors, including the response of fish stocks to pollutants, the responsiveness of consumers to price changes, and the magnitude of the perceived change in quality of the fish products. Recreational losses due to pollution are manifest in the catch rates of recreational fishers. Additionally, the potential exists for anglers to value fish less if they are afraid to consume the fish they catch because of the quality of the habitat. For any given fishing trip, a decrease in catch rates or reduced take-home catch because of pollution results in fewer benefits to the angler from the experience. Also, people may substitute less pleasurable activities for trips to catch fish from polluted waters. Some individuals may be willing to pay something to avoid pollution in fishery habitats even if they do not intend to go recreational fishing or to consume the fish. The principle way to measure these ''nonuse'' values is through direct questioning (contingent valuation) rather than by observing market behavior.

Liu, B.-c., N. Christiansen, et al. (1980). Measurement of the Socioeconomic Impact of Lake Restoration: An Assessment Model Employing a Benefit/Cost Cross-Impact Probabilistic Approach. *American Journal of Economics and Sociology 39*(3): 227-236.

A number of lake restoration demonstration projects have been launched by the Environmental Protection Agency as a result of Public Law 92-500. To evaluate the cost-effectiveness of these public investment projects requires the development of an assessment model. The proposed Benefit/Cost Cross-Impact Probabilistic Approach (BCCIPA) is one attempt at assessing the interdependent socioeconomic and environmental impacts of the lake restoration project over time, both quantitatively and qualitatively, so that various changes brought about by the project can be investigated and evaluated in two comparative stages for three points in time--before, during and after project implementation.

Maler, K. G., S. Aniyar, et al. (2009). Accounting for Ecosystems. *Environmental & Resource Economics* 42(1): 39-51.

Millennium Ecosystem Assessment documented the importance of ecosystem services. It is therefore important to include these services in the national system of economic accounts. This requires estimation of "accounting prices" for ecosystems, that is, the marginal value of a change in the size of the system. This raises a number of questions: What do we mean by the "size" of the system? What is the dynamics of the system? How do we quantify the impacts on services from a change in the size of the system and finally how do we value these impacts? We discuss these questions in a few examples of ecosystems, and valuation as such is not the major problem. The major problem is the lack of information of the appropriate dynamic model for most systems. We therefore suggest that economists and ecologists should set priorities on which ecosystems should be the first objects for study for these; we should test the possibilities of estimating the accounting prices.

Milon, J. W. and D. Scrogin (2006). Latent Preferences and Valuation of Wetland Ecosystem Restoration. *Ecological Economics* 56(2): 162-175.

We employ a latent class choice model to evaluate the effects of alternative ecological characterizations of wetland functions and services on individual preferences, and to determine whether socioeconomic factors and psychometric measures of environmental attitudes can explain differences in individual's preferences and values for wetland restoration. This analysis combines a multi-attribute choice model with information on individual's characteristics to evaluate preferences for restoration of the Greater Everglades ecosystem, one of the largest and most comprehensive wetland ecosystem restoration projects. To identify potential endpoints for Everglades restoration, two alternative ecological characterizations of the ecosystem were developed using the familiar distinction between function and structure. Survey data from a representative sample of the general population were used in a split-sample design based on the ecological characterization treatment. Within each subsample, the latent class analysis identified three groups who varied in their preferences for ecosystem restoration and socioeconomic profiles. The ecological characterizations had a significant influence on respondents' preferences and willingness to pay (WTP). The subsample responding to the structural characterization had a significantly larger share of respondents in the group who favored proposed restoration plans than the functional attribute subsample. In both subsamples, the group who favored restoration had a higher WTP for restoration than other groups. The latent class analysis also revealed socioeconomic and attitudinal factors that explain some of the heterogeneity in preferences and WTP within each subsample; this heterogeneity would not be identified with a standard choice model. In the context of Everglades restoration, the results provide a baseline assessment of public support and WTP that suggests an emphasis on structural rather than functional restoration endpoints. The approach described in this article can be used in other policy studies of wetland ecosystems because multiple ecosystem services can be represented within a stated choice survey and differences in preferences and values for these services can be measured.

Moberg, F. and C. Folke (1999). Ecological goods and services of coral reef ecosystems. *Ecological Economics* 29(2): 215-233.

This article identifies ecological goods and services of coral reef ecosystems, with special emphasis on how they are generated. Goods are divided into renewable resources and reef mining. Ecological services are classified into physical structure services, biotic services, biogeochemical services, information services, and social/cultural services. A review of economic valuation studies reveals that only a few of the goods and services of reefs have been captured. We synthesize current understanding of the relationships between ecological services and functional groups of species and biological communities of coral reefs in different regions of the world. The consequences of human impacts on coral reefs are also discussed, including loss of resilience, or buffer capacity. Such loss may impair the capacity for recovery of coral reefs and as a consequence the quality and quantity of their delivery of ecological goods and services. Conserving the capacity of reefs to generate essential services requires that they are managed as components of a larger seascape-landscape of which human activities are seen as integrated parts. (C) 1999 Elsevier Science B.V. All rights reserved.

Moeltner, K. and R. Woodward (2009). Meta-Functional Benefit Transfer for Wetland Valuation: Making the Most of Small Samples. *Environmental & Resource Economics* 42(1): 89-108.

This study applies functional Benefit Transfer via Meta-Regression Modeling to derive valuation estimates for wetlands in an actual policy setting of proposed groundwater transfers in Eastern Nevada. We illustrate how Bayesian estimation techniques can be used to overcome small sample problems notoriously present in Meta-functional Benefit Transfer. The highlights of our methodology are: (i) The hierarchical modeling of heteroskedasticity; (ii) The ability to incorporate additional information via refined priors; and (ii) The derivation of measures of model performance with the corresponding option of model-averaged Benefit Transfer predictions. Our results indicate that economic losses associated with the disappearance of these wetlands can be substantial and that primary valuation studies are warranted.

Muntean, O.-L., L. Dragut, *et al*. (2008). Environmental Impact Assessment as a Tool for Environmental Restoration: The Case Study of Copsa-Mica Area, Romania. Use of Landscape Sciences for the Assessment of Environmental Security, NATO Science for Peace and Security: Series C: Environmental Security. Dordrecht: Springer: 461-474.

This paper presents the roots and the consequences of the environmental degradation in Copşa Mică Area (Romania), as well as mitigation measures. The environmental impact assessment (EIA) and territorial analysis were applied on this environmental area. The assessment of the environmental decline was based on four categories of indicators: environmental, economic, social, and landscape structure and quality. We have established a set of relational environmental indicators, viewed as a tool for community development and enhancement of the environmental security. The methodology and results of the assessment (i.e. assessment matrix and a plan of environmental restoration) will be implemented into the process of local environmental planning.

Oh, C. O., R. B. Ditton, *et al*. (2008). The economic value of scuba-diving use of natural and artificial reef habitats. *Society & Natural Resources* 21(6): 455-468.

Artificial reefs may attract and sustain fish populations, but whether they resemble natural reefs is open to conjecture. This article addresses the question of whether artificial reefs are functionally acceptable to scuba divers. Research objectives were (1) to identify the nonmarket value of recreational scuba diving in offshore marine waters and (2) to ascertain whether the willingness to pay for scuba diving varied between users of natural and artificial reef habitats. A random sample of 1,059 scuba divers was used to estimate consumer's surplus associated with the diving experience. While natural and artificial habitats provide substantial economic value associated with diving, results indicate divers using natural reef habitats value their diving experience significantly more highly than those using artificial reef habitats. Also, substantial value from recreational diving use of artificial reefs suggests they serve as potential substitutes and thus may alleviate pressures on natural reef areas for conservation purposes.

Ojeda, M. I., A. S. Mayer, *et al*. (2008). Economic Valuation of Environmental Services Sustained by Water Flows in the Yaqui River Delta. *Ecological Economics* 65(1): 155-166.

We attempted to estimate the economic value of environmental services provided by restored instream flows in the water-scarce Yaqui River Delta in Mexico. The Yaqui River begins near the U.S.-Mexico border and continues for 400 km before reaching the Oviachic dam, but has not reached the nearby Gulf of California for decades due to diversions for irrigation. These diversions have degraded the riparian ecosystem, coastal wetlands, and estuaries. Environmental services provided by restored flows in the Yaqui River would include healthy riverside vegetation, wetlands and estuaries, fish and wildlife habitats, non-use values, and recreation. A contingent valuation survey in 40 neighborhoods in the most populated Delta city, Ciudad Obregon, was administered to estimate non-market values of instream uses. Respondents were given a current and hypothetical Delta scenario (the latter assumed restored water flows in the River) and asked a willingness-to-pay (WTP) question regarding purchasing water for environmental flows through higher water bills. Results from 148 in-person interviews indicated that households would pay an average of 73 pesos monthly. WTP was found related to key variables suggested by economic theory and contingent valuation studies elsewhere: income, educational level, number of children in the household, and initial bid amount. These results will allow decision makers to compare the benefits generated by different water uses, including environmental services, and to manage scarce water resources under a long-term sustainable approach.

O'Riordan, T. (1997). Valuation as Revelation and Reconciliation. *Environmental Values* 6(2): 169-183.

Valuation is portrayed here as a dynamic and interactive process, not a static notion linked to willingness to pay. Valuation through economic measures can be built upon by creating trusting and legitimizing procedures of stakeholder negotiation and mediation. This is a familiar practice in the US, but it is only beginning to be recognized as an environmental management tool in the UK. The introduction of strategic environmental and landuse appraisal plans for shorelines, estuaries, river catchments and rural landscapes, combined with the mobilization of protest around landuse proposals that are not seemingly justified on the basis of 'need' (incinerators, landfills, quarries, reservoirs, roads) suggest that a more legitimate participatory form of democracy is required to reveal valuation through consensual negotiation.

Palmer, M. A. and S. Filoso (2009). Restoration of Ecosystem Services for Environmental Markets. *Science* 325(5940): 575-576.

Ecological restoration is an activity that ideally results in the return of an ecosystem to an undisturbed state. Ecosystem services are the benefits humans derive from ecosystems. The two have been joined to support growing environmental markets with the goal of creating restoration-based credits that can be bought and sold. However, the allure of these markets may be overshadowing shortcomings in the science and practice of ecological restoration. Before making risky investments, we must understand why and when restoration efforts fall short of recovering the full suite of ecosystem services, what can be done to improve restoration success, and why direct measurement of the biophysical processes that support ecosystem services is the only way to guarantee the future success of these markets. Without new science and an oversight framework to protect the ecosystem service assets which people depend, markets could actually accelerate environmental degradation.

Park, T., J. M. Bowker, *et al.* (2002). Valuing snorkeling visits to the Florida Keys with stated and revealed preference models. *Journal of Environmental Management* 65(3): 301-312.

Coastal coral reefs, especially in the Florida Keys, are declining at a disturbing rate. Marine ecologists and reef scientists have emphasized the importance of establishing nonmarket values of coral reefs to assess the cost effectiveness of coral reef management and remediation programs. The purpose of this paper is to develop a travel cost--contingent valuation model of demand for trips to the Florida Keys focusing on willingness to pay (WTP) to preserve the current water quality and health of the coral reefs. The stated and revealed preference models allow the marginal valuation of recreationists to adjust depending on current and planned trip commitments in valuing nonmarginal policy changes in recreational opportunities. The integrated model incorporates key factors for establishing baseline amenity values for tourist dive sites, including perceptions of reef quality and dive conditions, the role of substitute sites, and the quality and availability of tourist facilities and recreation opportunities. The travel cost and WTP model differ in identifying critical variables and provide insight into the adjustment of trip decisions across alternative destination sites and the valuation of trips. In contrast to the travel cost model, a measure of the availability of substitute sites and total recreation activities does not have a significant impact on WTP valuations reported by snorkelers. Snorkelers engage in a relatively focused set of activities, suggesting that these recreationists may not shift expenditures to other sites or other recreation activities in the Florida Keys when confronted with increased access costs for the snorkeling experience.

Parsons, G. R. and S. M. Thur (2008). Valuing changes in the quality of coral reef ecosystems: A stated preference study of SCUBA diving in the Bonaire National Marine Park. *Environmental & Resource Economics* 40(4): 593-608.

We estimated the economic value of changes in the quality of a coral reef ecosystem to SCUBA divers in the Caribbean using a stated preference mail survey. Our sampling frame was all divers with U.S. home addresses who purchased a tag required for diving in the Bonaire National Marine Park in 2001. Divers were asked how they might have altered their trip choice had the quality of the coral reef system been different from what they experienced. From these responses we inferred the value of three different levels of quality defined by visibility, species diversity, and percent coral cover. We used random utility theory and mixed logit to analyze the choice questions. Our sample size was 211, and our survey response rate was 75%. For modest changes in quality we estimated per person annual losses at $45. For larger losses the value was $192.

Petrolia, D. R. and T.-G. Kim (2009). What Are Barrier Islands Worth? Estimates of Willingness to Pay for Restoration. *Marine Resource Economics* 24(2): 131-146.

A dichotomous-choice contingent-valuation survey was conducted in the State of Mississippi (USA) to estimate willingness to pay (WTP) for three restoration options being considered for the state's barrier islands. Random-effects probit models were estimated, and parametric and non-parametric WTP estimates and confidence intervals were calculated. Turnbull lower-bound mean WTP was $22 per respondent to maintain the existing footprint over a 30-year period, $152 to restore 2,338 acres (pre-1969 footprint), and $277 to restore 5,969 acres (pre-1900 footprint). Econometric results indicate that for the Pre-Camille and Pre-1900 options, coastal residents and those citing storm protection, recreation impact, and environmental impact as primary decision factors, were more likely to support restoration, with marginal effects of these greater for the Pre-Camille option. For the Status-Quo option, 75% of respondents voted in favor of restoration, and the offered bid was not significant; only the hurricane-protection and environmental-impact variables were significant for this option.

Ross, A. and A. Stockdale (1996). Multiple Environmental Designations: A Case Study of Their Effectiveness for the Ythan Estuary. *Environment and Planning C: Government and Policy* 14(1): 89-100.

High-value landscapes, habitats, and species are protected increasingly through a range of local, national, and international designations and policies. Often one site may be protected by a multitude of designations. However, international designations are commonly implemented through national mechanisms. Using the Forvie Sands and Ythan Estuary area of northeast Scotland as an example, we review the effectiveness of multiple environmental designations. After an examination of existing and proposed designations for the study area, overlaps and loopholes in environmental protection are identified. We conclude that protection from more than one designation may either afford the site additional protection or emphasise the importance of the site at different levels; local, national, and international. The principal loophole relates to unregulated activities undertaken beyond the designated site which may have an adverse effect on the protected area. Possible solutions include extending the designation to include the sources of the threat or to combine an appropriate designation strategy with effective regulation of the threat itself. In developing designation strategies, environmental protection agencies should consider these options.

Sanchirico, J. N. and P. Mumby (2009). Mapping ecosystem functions to the valuation of ecosystem services: implications of species-habitat associations for coastal land-use decisions. *Theoretical Ecology* 2(2): 67-77.

Habitats and the ecosystem services they provide are part of the world's portfolio of natural capital assets. Like many components of this portfolio, it is difficult to assess the full economic value of these services, which tends to over-emphasize the value of extractive activities such as coastal development. Building on recent ecological studies of species-habitat linkages, we use a bioeconomic model to value multiple types of habitats as natural capital, using mangroves, sea grass, and coral reefs as our model system. We show how key ecological variables and processes, including obligate and facultative behaviors map into habitat values and how the valuation of these ecological processes can inform decisions regarding coastal development (habitat clearing). Our stylized modeling framework also provides a clear and concise road map for researchers interested in understanding how to make the link between ecosystem function, ecosystem service, and conservation policy decisions. Our findings also highlight the importance of additional ecological research into how species utilize habitats and that this research is not just important for ecological science, but it can and will influence ecosystem service values that, in turn, will impact coastal land-use decisions. While refining valuation methods is not necessarily going to lead to more rational coastal land-use decisions, it will improve our understanding on the ecological-economic mechanisms that contribute to the value of our natural capital assets.

Smith, M. A. (2007). Generating value in habitat-dependent fisheries: The importance of fishery management institutions. *Land Economics* 83(1): 59-73.

This paper models dynamic producer and consumer benefits from improving habitat that supports the North Carolina blue crab fishery. It embeds two fishery management institutions-open access and partial rationalization-in a multispecies, two-patch spatial bioeconomic model with endogenous output price and estuarine eutrophication. Producer benefits from improved environmental quality, are higher for the rationalized fishery than,for open access. Consumer benefits are larger than producer benefits and are comparable across institutions. However, the total benefits from improving environmental quality are small relative to the benefits from rationalizing the,fishery and leaving environmental quality the same.

Smith, M. D. and L. B. Crowder (2005). Valuing Ecosystem Services with Fishery Rents: A Lumped-Parameter Approach to Hypoxia in the Neuse River Estuary, *Fondazione Eni Enrico Mattei, Working Papers*: 2005.115.

Valuing ecosystem services with microeconomic underpinnings presents challenges because these services typically constitute nonmarket values and contribute to human welfare indirectly through a series of ecological pathways that are dynamic, nonlinear, and difficult to quantify and link to appropriate economic spatial and temporal scales. This paper develops and demonstrates a method to value a portion of ecosystem services when a commercial fishery is dependent on the quality of estuarine habitat. Using a lumped-parameter, dynamic open access bioeconomic model that is spatially explicit and includes predator-prey interactions, this paper quantifies part of the value of improved ecosystem function in the Neuse River Estuary when nutrient pollution is reduced. Specifically, it traces the effects of nitrogen loading on the North Carolina commercial blue crab fishery by modeling the response of primary production and the subsequent impact on hypoxia (low dissolved oxygen). Hypoxia, in turn, affects blue crabs and their preferred prey. The discounted present value fishery rent increase from a 30% reduction in nitrogen loadings in the Neuse is $2.56 million, though this welfare estimate is fairly sensitive to some parameter values. Surprisingly, this number is not sensitive to initial conditions.

Soderqvist, T., H. Eggert, et al. (2005). Economic valuation for sustainable development in the Swedish coastal zone. *Ambio* 34(2): 169-175.

The Swedish coastal zone is a scene of conflicting interests about various goods and services provided by nature. Open-access conditions and the public nature of many services increase the difficulty in resolving these conflicts. "Sustainability" is a vague but widely accepted guideline for finding reasonable trade-offs between different interests. The UN view of sustainable development suggests that coastal zone management should aim at a sustainable ecological, economic, and social-cultural development. Looking closer at economic sustainability, it is observed that economic analyses about whether changes in society imply a gain or a loss should take into account the economic value of the environment. Methods used for making such economic valuation in the context of the Swedish coastal zone are briefly reviewed. It is noted that the property rights context matters for the results of a valuation study. This general background is followed by a concise presentation of the design and results of four valuation studies on Swedish coastal zone issues. One study is on the economic value of an improved bathing water quality in the Stockholm archipelago. The other studies are a travel cost study about the economic value of improved recreational fisheries in the Stockholm archipelago, a replacement cost study on the value of restoring habitats for sea trout, and a choice experiment study on the economic value of improved water quality along the Swedish west coast.

Spash, C. L. (2002). Informing and forming preferences in environmental valuation: Coral reef biodiversity. *Journal of Economic Psychology* 23(5): 665-687.

The level and depth of information provision required for making informed judgments over environmental options has remained troublesome in various contexts from individual choice through to international policy. In the valuation literature concern has been expressed for 'information bias' leading to distorted estimates of the worth of environmental entities (e.g., wildlife, ecosystems) because peoples intentions are formed during the valuation process by the information provided. Contending psychological models on the role of information and its relationship to ethical concerns are reviewed with respect to public decision processes over environmental entities. The robustness of pre-existing environmental preferences is then linked to ethical positions but their role is unclear. Empirical evidence is reported from a contingent valuation method study of coral reef biodiversity on the strong connections between informing and forming preferences and specific ethical beliefs regarding environmental entities.

Stal, J., S. Paulsen, et al. (2008). Coastal habitat support to fish and fisheries in Sweden: Integrating ecosystem functions into fisheries management. *Ocean & Coastal Management* 51(8-9): 594-600.

This study adopts an interdisciplinary approach, where ecological data on habitat structure and fish populations are combined with results from economic valuation case studies to assess effects of habitat disturbance. The focus is on three major habitats (soft sediment bottoms, seagrass beds and rocky bottoms with macroalgae), five fish species (cod, plaice, eel, mackerel and sea trout) and three types of fisheries (commercial, subsistence and recreational fisheries). The results have important implications for coastal zone management, demonstrating both ecologically and economically how coastal habitats support fisheries.

Stevens, T. H., S. Benin, et al. (1995). Public-Attitudes and Economic Values for Wetland Restoration in New England. *Wetlands* 15(3): 226-231.

Wetland preservation produces two types of economic value: use value and nonuse (existence) value. Previous studies have focused almost exclusively on use value, yet nonuse value is becoming increasingly important, in part because it is now considered by the courts in natural resource damage assessments. This study uses the contingent valuation survey technique to estimate the total economic value of wetland preservation in New England. Respondents were willing to pay an average of between 74 and 80 dollars per year (over a five-year period) for wetlands providing flood protection, water supply, and water pollution control and between 81 and 96 dollars per year for wetlands containing rare species of plants. Aggregate value estimates ranged between 242 and 313 million dollars per year. Survey results suggest that most of this value is nonuse value-failure to consider nonuse values in decision making can therefore understate the value of preservation by a substantial margin.

Su, T. and E. D. Zhang (2007). Ecosystem valuation and the conservation of wild lands in vigorous economic regions: A case study in Jiuduansha Wetland, Shanghai. *Chinese Science Bulletin* 52(19): 2664-2674.

As the loss of wild lands to satisfy traditional economic development has become a global environmental problem in recent decades, using ecosystem valuation to estimate the total economic value (TEV) of an ecosystem has become popular. The main purpose of the ecosystem valuation is to strengthen the importance of ecosystems, and bring the ecosystem services into the traditional cost-benefit analyses of land use strategy. Some studies have illustrated that in remote areas, wilderness can produce more value if it is conserved, rather than converted to traditional agricultural or industrial uses. The same situation does not seem to exist in vigorous economic regions. Thus, a case study was conducted on the Jiuduansha Wetland in Shanghai using three approaches: the direct market valuation, the replacement valuation and the contingent valuation. The net present TEVs of three land use scenarios over one hundred years were evaluated. The results proved that simply based on ecosystem valuation, when compared with the other two scenarios of "conservation" and "selective use", "partial conversion into terrene (dry land)" of Jiuduansha might be the optimal scenario for the well-being of the people in Shanghai. Land price was identified as the most important factor. This situation is likely due to the scarcity of land available for traditional economic development in Shanghai. Thus, we speculated that the fate of the wilderness to "be destroyed" in vigorous economic regions could not be changed simply based on ecosystem valuation. However, the variety of interest by local residents in wilderness might enhance the TEVs of scenarios such as "conservation" and "selective use", and affect the valuation results. Since some important benefits of natural ecosystems remain unknown and others are underestimated, we suggested that any land use decisions regarding the Jiuduansha Wetland should be conservative and cautious as converting wetlands into terrene is an irreversible process.

Tapsuwan, S., G. Ingram, et al. (2009). Capitalized amenity value of urban wetlands: a hedonic property price approach to urban wetlands in Perth, Western Australia. *Australian Journal of Agricultural and Resource Economics* 53(4): 527-545.

Up to 60 per cent of potable water supplied to Perth, Western Australia, is extracted from the groundwater system that lies below the northern part of the metropolitan area. Many of the urban wetlands are groundwater-dependent and excessive groundwater extraction and climate change have resulted in a decline in water levels in the wetlands. In order to inform decisions on conserving existing urban wetlands, it is beneficial to be able to estimate the economic value of the urban wetlands. Applying the Hedonic Property Price approach to value urban wetlands, we found that distance to the nearest wetland and the number of wetlands within 1.5 km of a property significantly influence house sales price. For a property that is 943 m away from the nearest wetland, which is the average distance to the wetland in this study, reducing the wetland distance by 1 m will increase the property price by AU$42.40. Similarly, the existence of an additional wetland within 1.5 km of the property will increase the sales price by AU$6976. For a randomly selected wetland, assuming a 20 ha isolated circular wetland surrounded by uniform density housing, the total sales premium to surrounding properties was estimated to be around AU$140 million (AU$40 million and AU$230 million).

Tseng, W. C. and C. C. Chen (2009). Estimating the wetland rental fee: a case study involving a Taiwan wetland. *Applied Economics* 41(24): 3179-3188.

Wetlands provide many functions that are both economic and recreational and are valuable in terms of their ecological diversity, while at the same time being nonmarket value products. The purpose of this study is to estimate the optimal wetland rental through estimations of both the demand and supply functions in relation to wetland. The wetland supply function is directly estimated based on the data provided by the owners of the wetland, while the estimation of the wetland input demand function involves using the bootstrapping and contingent visitation approaches. Such estimation approaches could also be applied to other nonmarket value products that give rise to environmental externalities. The estimation of rental fee could provide a long-term leasing contract that gives the landlord with a particular rent to lease their lands to support a wetland eco-tourism park to maintain wetland for substantial management. Several environmental management policy implications are also addressed.

Weisskoff, R. (2000). Missing Pieces in Ecosystem Restoration: The Case of the Florida Everglades. *Economic Systems Research* 12(3): 271-303.

The largest ecosystem restoration in the world--a $7.8 billion rescue package--is now beginning in the Florida Everglades. This paper examines both the economic impact of the restoration itself and those pieces that are "missing" from the official project analysis; namely, increased tourism, urban construction, in-migration, and changing agricultural patterns. These pieces comprise a variety of scenarios that are tested for a 45 year planning period with an augmented input-output model derived from a regional SAM. The new output and employment generated by the "missing pieces", which are small relative to the vast economic base of the region, do represent a considerable increase over the annual growth, especially by the year 2045. We conclude with a discussion of ways in which a growing regional economy might be reconciled with ecosystem restoration.

Weisskoff, R. (2005). The Economics of Everglades Restoration: Missing Pieces in the Future of South Florida, Cheltenham, U.K. and Northampton, Mass.:Elgar.

Critiques the original U.S. Army Core of Engineers restoration plan for the Florida Everglades, arguing that the future economic growth of the region has not been properly taken into account. Projects how many people and jobs and how much output are to be expected by 2035 and compares these forecasts with other projections made by "official" sources. Applies these economic projections to gain insight into the future demand for water and the future demand for urban land in the region. Discusses the role of the economy as the primary stressor of the Everglades. Provides a statistical review of the South Florida economy; a brief history of the great public works that have resulting in the "carving up" of South Florida; a comparison of the population growth of Florida's regions; a quantitative study of agriculture; and estimates of the value of ecosystem services in the region based on two recent land use surveys. Introduces the reader to the comparative strengths of the two regional models used in the forecasting process. Examines various data sources and corrects the control model by incorporating estimates of income generated by agriculture; the components of investment; tourist spending; and all expected spending on Everglades's restoration. Presents findings and considers alternative future paths for Florida. Weisskoff is Associate Professor teaching economics in the Department of International Studies at the University of Miami, Coral Gables. Bibliography; index.

Weslawski, J. M., E. Andrulewicz, *et al*. (2006). Basis for a valuation of the Polish Exclusive Economic Zone of the Baltic Sea: Rationale and quest for tools. *Oceanologia* 48(1): 145-167.

This paper summarizes current knowledge of goods and services in the Polish Exclusive Economic Zone of the Baltic Sea ecosystem. It reviews specific properties of the Baltic that could be used for economic valuation. Goods and services range from the familiar resources, of fish and minerals, which were valued with the Productivity Method, to less obvious services provided by the ecosystem such as biofiltration in coastal sands, valued with either the Replacement Cost or Damage Cost Avoided methods. Disservices to the marine ecosystem are also considered, e.g., erosion and coastal flooding, including the costs of planned mitigating measures. This paper emphasizes the importance of using valuation methods to help make better-educated decisions for the sustainability of the Baltic Sea.

White, A. T., H. P. Vogt, *et al*. (2000). Philippine coral reefs under threat: The economic losses caused by reef destruction. *Marine Pollution Bulletin* 40(7): 598-605.

In the Philippines, coral reef fisheries provide livelihood for more than a million small-scale fishers who contribute almost US$ 1 billion annually to the country's economy. The rapidly growing population needs increasing amounts of fish and other marine organisms. However, overfishing, destructive fishing methods and sedimentation have damaged or destroyed many reef areas. Fish catches have fallen well below the sustainable levels of healthy reefs. The economic losses to the coastal fishing population are considerable. Various programmes have and are trying to counter

coral reef decline by establishing sustainable management regimes. The economic benefits of such programmes appear to exceed their investment costs. As an example, the start-up and maintenance costs of a successful island marine reserve project have been compared to the losses caused by reef destruction and the gains from reef management. The results clearly show that the economic benefits from a managed reef area due to higher catches and revenue from small-scale tourism far exceed costs. Coral reefs are also a major attraction for an increasing number of local and international tourists. In addition to providing income for the tourism industry, these reef visitors are often willing to contribute to the costs for reef management. The annual willingness-to-pay assessed in three popular diving destinations is significant. An estimated US$ 300 000 could be collected annually as entrance fees or donations in Mabini, Batangas alone. It is estimated that the 27 000 km (2) of reef in their degraded condition still contribute at least US$ 1.35 billion annually to the economy. Reef management involving local fishing communities, local governments and other concerned organizations is a cost-effective way to alleviate the pressure on the numerous threatened coral reefs. In addition, economic valuation and cost-benefit analysis can provide essential information to support more investment in reef conservation. (C) 2000 Elsevier Science Ltd. All rights reserved.

Whitehead, J. C., T. L. Hoban, *et al*. (1997). Economic analysis of an estuarine quality improvement program: The Albemarle-Pamlico system. *Coastal Management* 25(1): 43-57.

As part of the National Estuary Program, the extensive 5-year Albemarle-Pamlico Estuarine Study was recently concluded. The resultant Comprehensive Conservation and Management Plan was designed to maintain the ecological integrity of the estuary through long-term planning and management. One of the components of this plan is the consideration of human dimensions of the Albemarle-Pamlico system, including benefits and costs for present and future generations. This article presents an economic efficiency analysis of the proposed management plan. Under plausible conditions and reasonable data for benefits and costs, it appears that the management plan would be an efficient government program if the negative externalities associated with economic growth of the Albemarle-Pamlico region are controlled.

Wielgus, J., N. E. Chadwick-Furman, *et al*. (2002). Dose-response modeling of recreationally important coral-reef attributes: a review and potential application to the economic valuation of damage. *Coral Reefs 21*(3): 253-259.

Dose-response modeling has been widely used to document links between anthropogenic stressors and ecosystem attributes, and as a basis in the economic valuation of pollution damage. We review studies on the relation between anthropogenic stress factors and coral-reef attributes valuable in recreation, discuss the components of the economic value of coral reefs, and examine the potential use of dose-response functions in the economic valuation of coral-reef damage.

Winkler, R. (2006). Valuation of ecosystem goods and services: An integrated dynamic approach. *Ecological Economics* 59(1): 82-105.

This is the first part of a two-part paper which offers a new approach to the valuation of ecosystem goods and services. The existing literature on environmental valuation is based on two distinct foundations. The ecological valuation methods derive values by a cost-of-production approach. Their common characteristic is the neglect of consumer preferences. The economic valuation methods focus on the exchange value of ecosystem services. Their common characteristic is that they are finally based on consumer preferences, and do not adequately take account of the complex internal structure of ecosystems. As the existing methods for the valuation of ecosystem services emphasize either the economic system or the ecosystem, the main objective of part 1 is to provide the conceptual foundations for a new method of valuation of ecosystem services, which deals simultaneously with the ecosystem, the economic system and society in a balanced way. Within a simple pre-industrial model it is shown how the interdependencies between the three subsystems influence values, and how values change over time.

Woodward, R. T. and Y. S. Wui (2001). The economic value of wetland services: a meta-analysis. *Ecological Economics* 37(2): 257-270.

The number of studies quantifying the value of wetlands and the services provided by these ecosystems is rapidly expanding. The time is ripe for an assessment of what has been learned from this literature. Using results from 39 studies, we evaluate the relative value of different wetland services, the sources of bias in wetland valuation and the returns to scale exhibited in wetland values. While some general trends are beginning to emerge, the prediction of a wetland's value based on previous studies remains highly uncertain and the need for site-specific valuation efforts remains large. (C) 2001 Elsevier Science B.V. All rights reserved.

Wu, J. (2003). Pacific Salmon Restoration: Trade-Offs between Economic Efficiency and Political Acceptance. *Contemporary Economic Policy* 21(1): 78-89.

There is no simple solution to the problems of salmon restoration given substantial political and scientific uncertainties. There are, however, some local findings in Oregon that can provide guidance to resource managers charged with allocating funds for conservation purposes. This article shows that in most salmon habitat investments, there are likely to be strong nonlinearities (cumulative and threshold effects) that mitigate against politically palatable allocation criteria. In fact, this research indicates that decisions based on political equity concerns may actually lead to the lowest possible benefits to society. These scientific nonlinearities may make the political resolution of salmon recovery more difficult.

Yang, W., J. Chang, *et al.* (2008). Ecosystem service value assessment for constructed wetlands: A case study in Hangzhou, China. *Ecological Economics* 68(1-2): 116-125.

Based on a comprehensive analysis of various classifications of natural resource values, we summarized an ecological economic value system of constructed wetland

(CW) ecosystems for treating eutrophic water. Using the CW located at the Hangzhou Botanical Garden as an example, the contingent valuation method (CVM) and shadow project approach (SPA) were applied to estimate the economic values of CW system ecosystem services. The CVM estimated a value of 800,000 yuan (yuan: Chinese Currency, 7.6 yuan=1 USD as of August, 2007) as the total economic value of the CW in a twenty year period. Meanwhile, the SPA calculated a value of 23.04 million yuan as the total economic value of the CW in a twenty year period. It is determined that compared to the CVM, the SPA provides a more approximate value of the true monetary value of the Hangzhou Botanical Garden CW. This study could fill the gap of knowledge and provide a benchmark when evaluating constructed ecosystem services and help policy makers to promote the development of constructed wetlands in China. (C) 2008 Published by Elsevier B.V.

Zhongmin, X., J. Loomis, *et al*. (2006). Evaluating the Performance of Different Willingness to Pay Question Formats for Valuing Environmental Restoration in Rural China. *Environment and Development Economics* 11(5): 585-601.

This paper compares protest rates and willingness to pay (WTP) using a payment card versus single and double bounded voter referendum contingent valuation question formats. Using a chi-square test, the payment card had a significantly higher protest rate (6.7 per cent) than the voter referendum question format (2.2 per cent). The median WTP of the single bounded and double bounded referendum format exceeds the payment card by a factor of nine and seven, respectively. The median WTP from the referendum formats represent about 8 per cent of income, while the payment card results represents about 1 per cent of income. These large differences in WTP between question formats are double what have been found in past studies. We believe this result may be due to excessive yea saying at high bid amounts in the dichotomous choice question formats. This behavior may arise in our case study in rural China because citizens have not had a long history of open elections or voting on tax referenda.