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Valuing Estuarine Resource Services Using Economic and Ecological Models: The Peconic Estuary System Study

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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.

Keywords estuarine resources, nonmarket valuation, Peconic, resource values

Introduction

Coastal managers increasingly request quantitative methods for prioritizing management actions that explicitly account for economic and social factors (Chua 1993; Christie & White 1997; Ruddle, 1988). One common method of linking economic and ecological outcomes involves assessments of the economic consequences of ecological management outcomes—often using either market or nonmarket valuation techniques (Freeman, 1993). Several methods may be used to assess the value of coastal resource goods and services, depending upon the resources in question and the specific issues of concern. However, one limitation of valuation methods used in isolation is that they may quantify values for only a subset of the many relevant resource goods and services, providing only a partial view

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of management benefits. A second limitation of isolated valuation methods is that they may not allow comparisons of values generated by different resources, or received by different stakeholder groups. Without such input, managers may lack information necessary to compare policies that address different types of coastal resources.

Total economic value is generally composed of a number of different types of market and nonmarket value, associated with different aspects of natural resource goods and services. No single method can capture the economic value of the many, disparate services provided by the natural assets of any coastal region. However, given a lack of familiarity with nonmarket valuation approaches, there is a risk that policy audiences may assume that a single methodology provides the "true value" of the resource in question—ignoring the fact that different methodologies may estimate different aspects of value. As most research studies apply a single market or nonmarket valuation methodology, the critical differences among benefit estimates provided by different methodologies can be obscured, leaving policy makers with an incomplete understanding of the appropriate use of economics with coastal management (Johnston et al., 2001). As it is rarely practical or cost-effective to apply more than one or two valuation methodologies to any particular policy question, the choices among competing approaches can have important implications for estimated benefits and costs. In this context, it is critical that managers have a sufficient understanding of the economic methods brought to bear on coastal policy issues, and implications for specific type of resources addressed and values measured.

This article summarizes a comprehensive environmental economics research program conducted as part of the multidisciplinary Peconic Estuary Program. The purpose of this presentation is to promote recognition of the disparate economic benefits associated with different aspects of estuary management, and the methods that may be appropriately used to measure these benefits. The article is organized as follows. First, we briefly describe the study area and motivation for the reported research. We then present the four nonmarket valuation studies that comprise the Peconic Estuary research program, each designed and implemented in coordination with physical scientists and coastal managers. In each case, we summarize the rationale for the study, outline the methodology and data employed, and present key results.

Throughout the article, we emphasize issues that arise in comparing results of different methodologies, and implications of such findings for management. The principal goals of this presentation are to highlight different approaches 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 interpretation and potential summation of estimated economic values.

The Peconic Estuary System

Located within Suffolk County at the East End of Long Island, the Peconic Estuary System (PES) is comprised of the Peconic-Flanders Bays system, Gardiners Bay and part of Block Island Sound, and the adjoining watershed lands. The PES includes five communities: East Hampton, Southampton, Riverhead, Southold, and Shelter Island, as well as a small part of Brookhaven (Figure 1). In total, the PES comprises about 38 percent of the land area and 8 percent of the year-round population of Suffolk County (Suffolk County Dept. of Health Services (SCDHS), 1992; Long Island Business News 1994).

The PES contains a wide range of valued coastal resources, including fisheries,

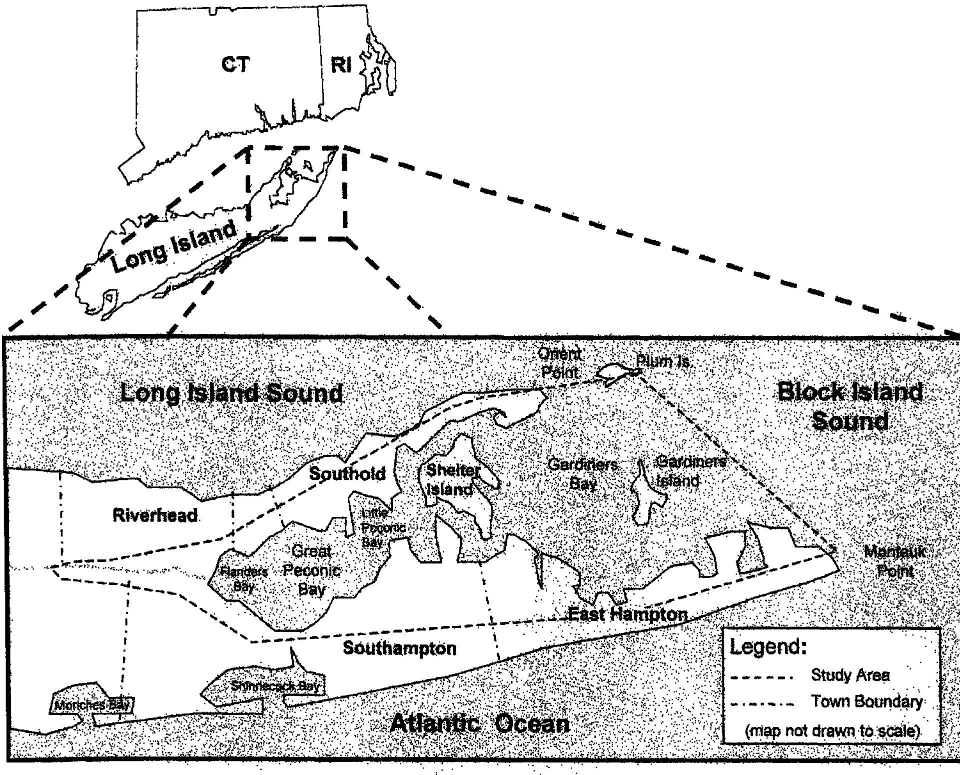

Figure 1. Depiction of the Peconic Estuary System.

beaches, parks, open space, and wildlife habitat. However, current development and resource uses place many of these resources at risk (SCDHS, 1992). For example, localized water quality problems exist due to runoff, failing septic systems, and inadequate sewage treatment. Development has caused the loss of substantial areas of open space and large areas of ecologically productive salt marsh. Pollution has closed thousands of acres of commercial and recreational shellfish beds, and eelgrass beds have been substantially diminished due to outbreaks of brown tide. In part due to the loss of eelgrass and salt marsh nursery areas, as well as the loss of open harvest areas, fin and shellfish landings have declined substantially during recent years.

While the quality of—and threats to—PES coastal amenities are widely recognized, little systematic information exists about economic value of the natural asset services of this region, as realized by different resident and visitor groups. Without information on recreational and other nonmarket resource values, decision makers lack sufficient information to appropriately compare the economic benefits and costs of prospective actions to preserve or restore PES natural assets. Thus, while baseline ecological and other studies have identified degradation in a wide range of coastal resources, the impact of the potential lost resource services on society has not been quantified, nor have the benefits of potential policy remedies been assessed.

Estuarine Resource Service Values

Coastal resources may be viewed as natural assets that provide a stream of valuable services over time (Freeman, 1993; Kopp & Smith, 1993). Estuarine resource services can be direct (e.g., beach use, commercial fish catch), or indirect (e.g., the contribution of coastal wetlands to the natural production of fish harvested elsewhere). Moreover, services may be traded in traditional markets with market prices and values (e.g., commercial fish), or may be available outside of traditional markets, so that nonmarket approaches are needed to estimate social values (e.g., recreational fishing and wildlife viewing).

Much of what residents and visitors value in the PES—for example, the quality of the area's natural amenities, like open space, attractive views, good beaches, high levels of water quality, and fish and shellfish resources used for recreation—are not bought and sold in markets. The value of these services, therefore, is often omitted in traditional economic impact studies, or is not linked to the natural asset that provides the service (e.g., shell fish produced by PES wetlands and later harvested by recreational fishers; the effect of aesthetic amenities on property values). As a result, the value the public holds for environmental and natural resource services may be under-appreciated or ignored, the latter implicitly assigning them a value of zero.

Given the diversity of resource issues in the coastal zone, multiple studies may be required to assess the full range of relevant nonmarket values. While single valuation methodologies may provide valuable information, they may also create the false impression that resources or resource values not addressed by the methodology in question have negligible economic value. However, in reality, different measurement methodologies often address different components of total economic value (Johnston et al., 2001; Freeman, 1993). Hence, a carefully coordinated combination of different economic methodologies can provide a more complete understanding of social and economic values associated with coastal resource services.

For example, for activities like swimming, boating, and recreational fishing, which involve direct use of bay waters, policy makers may wish to measure participants' recreational use values. In other cases, coastal resources may provide amenity or aesthetic benefits to nearby residents, which are reflected in local property values. Additionally, some residents or visitors may enjoy the simple knowledge that environmental amenities, such as open space and salt marshes, are preserved or restored, whether or not they directly use these resources. No single valuation methodology can measure and distinguish these different aspects of economic value—which in themselves only represent a fraction of the many coastal resource services which may be valued by the public. In such cases, a combination of different methodologies—each designed to measure a different aspect of nonmarket value—may provide an improved understanding of the values provided by a estuarine resource services, and the tradeoffs involved in directing management funds to specific resource areas. In other cases, an improved understanding of the different types of values that exist—and of those values likely to dominate in a given situation—may help researchers determine which valuation approaches are most appropriate in different management scenarios.

To illustrate the range of nonmarket economic values that may be associated with natural resources in a single coastal region, this article summarizes four coordinated, nonmarket valuation studies designed and implemented in the PES. Each study allows policy makers to translate changes in specific natural assets into a change in services and, ultimately, to quantified economic effects. We place particular emphasis on issues that arise when comparing or attempting to sum benefit estimates from different types of studies. Such issues are rarely discussed in the management literature, leading to potential misconceptions regarding the proper use and interpretation of economic benefit estimates. Those interested in a more extensive discussion of the analytical details, data, model assumptions and statistical results of particular models are referred to Opaluch et al. (1999) and Johnston et al. (2001). The four studies are as follows:

1. *A Property Value* study examines the contribution of environmental amenities to the market price of property. Using the Town of Southold as a case study, this study was designed to measure the implicit values of policy-relevant scenic amenities to nearby residents.
2. *A Travel Cost* study estimates the economic value that users have for four key PES outdoor recreation activities: swimming, boating, fishing, and bird and wildlife viewing. This study also examines the impact of (1) water quality on the number of trips by, and the value of swimming to, participants and (2) catch rates on recreational fishing.
3. *A Wetlands Productivity Value* study provides estimates of the economic value of eel-grass, inter-tidal salt marsh, and sand/mud bottoms, based on the value of the fish, shell-fish and bird species that these ecosystems help produce. The focus is on the nursery and habitat services of wetland ecosystems in the production of commercial fisheries.
4. *A Resource Value* study uses contingent choice methodology to estimate the relative preferences that residents and second homeowners have for preserving and restoring key PES natural and environmental resources, including open space, farmland, unpolluted shellfish grounds, eelgrass beds, and inter-tidal salt marsh. This study also provides an estimate of the public's willingness to pay, or economic value for these resources.

It is important to recognize that the resource values estimated by each of the four approaches are, in many cases, realized by different resident or non-resident groups. For example, the property value study assesses values realized by local residents, while the travel cost analysis estimates values received by both local residents and tourists. The wetland productivity study, in contrast, measures economic values realized both on-site (e.g., wildlife viewing and hunting values) and off-site (commercial fish harvest) by a range of resident and non-resident user groups. Hence, decisions among various valuation approaches are often made in coordination with decisions regarding which groups have standing in a particular benefit-cost analysis (Boardman et al., 2001).

The Property Value (Hedonic) Study

The Town of Southold on the North fork of the PES (cf. Figure 1) was used as a case study for a property value (hedonic) analysis of scenic amenity resource services.[1] Southold has a long and varied coastline, both on the Peconic Estuary and on Long Island Sound, and is characterized by a variety of development types. About a quarter (26%) of the town is currently in agricultural use, compared to 30% in residential use, 12% in preserved open space, and 18% classified as vacant. Less than 3% is classified as commercial or industrial (Suffolk County Department of Planning 1997a). Although the town retains large areas of farmland and open space, its population density (0.67 persons per acre) is highest among the five PES towns. As in all PES communities, Southold is facing the prospect of rapid residential and commercial growth (Suffolk County Department of Planning, 1997b). Within this environment of rapid change, many policy choices involve land use—the protection of open space, undeveloped land, and other land-based environmental amenities.

Although the Suffolk County Planning Department maintains a detailed Geographic Information System (GIS) database covering the Town of Southold, raw land-use data alone cannot indicate the impact of land use policy changes on local residents. However, these data can often provide a significant component of the raw data necessary to implement a hedonic property value study (Freeman, 1993). Using the hedonic approach, researchers can estimate the impact of land use or environmental attributes on the observed value (selling price) of local property. These results reveal home buyers' actual willingness to pay to obtain increased levels of desired land use or environmental attributes associated with particular properties—or the implicit value of these attributes to local residents.

Hedonic property value analysis is a standard means of estimating residents' use value for certain types of environmental changes (e.g., Braden and Kolstadt, 1991; Freeman, 1993). The technique is based on the premise that environmental amenities provide valued services, making nearby properties with a high level of valued environmental amenities more attractive, and therefore more valuable, than similar properties with a lower level of such amenities.[2]

The statistical model simultaneously compares a large number of properties with different prices and attributes, including site, neighborhood, and environmental characteristics. Attributes may include, for example, the size of the house, size of the lot, number of bedrooms, bathrooms, fireplaces, presence of a garage, the year the house was built, the attributes of the neighborhood, and many other characteristics that one would expect to influence the price of residential property. The method then estimates the change in property value related to changes in each particular attribute, holding all other attributes constant. When applied to an environmental amenity, the model estimates the value of the services that the amenity provides to members of the surrounding community, as measured by the incremental willingness to pay to buy a property that provides the environmental amenity (e.g., an ocean view), as compared to an otherwise identical property that does not provide (or provides less of) the amenity in question.

For this study, the property value model was applied using sales data for all real estate parcels sold in the Town of Southold during 1996. The model combines data gathered from Town of Southold property record cards for all properties sold during 1996 with land use and other data gathered from the computerized geographic information system (GIS) maintained by the Suffolk County Planning Department. Altogether, the data include full information on 374 parcels of land.

Model results provide insight into the economic gains and losses associated with numerous potential policies, including open space preservation, re-zoning, and highway construction in the coastal zone.[3] A full description of the methodology and results is provided by Johnston et al. (2001). Principal findings of the first-stage hedonic analysis include:

1. A parcel of land located adjacent to preserved open space has, on average, 12.8% higher per-acre value than a similar parcel located elsewhere.
2. A parcel of land located adjacent to farmland has, on average, a 13.3% lower per-acre value than a similar parcel located elsewhere.
3. A parcel of land located next to a major area highway has, on average, a 16.2% lower per-acre value than a similar parcel located elsewhere.
4. A parcel of land located within a district zoned R-80 (two-acre zoning) or R-120 (three-acre zoning) has, on average, 16.7% higher per-acre value than a similar parcel located elsewhere.

Model results indicate that environmental policies in the PES can significantly impact the local quality of life, as reflected in residents' willingness to pay to live in specific areas characterized by specific resource services. Combined with GIS technology, these results also provide a framework through which the marginal property value impacts of specific land use changes—incorporated in an overall estuary management plan—may be forecast. For example, hedonic results here suggest that zoning variances allowing more dense development in existing R-80 or R-120 zones would have a negative influence on the per-acre property values of nearby homeowners, representing a negative influence on local quality of life.

As with all nonmarket valuation methodologies, the hedonic methodology measures a specific aspect of value associated with natural resources. In this case, the hedonic model measures capitalized economic values associated with the direct and indirect use of nearby resources by coastal residents. Hedonic results therefore allow estimation of use values related to resources that affect the choice of housing properties—that is, resources whose value changes depending on where a resident chooses to live or purchase property. Hedonic models cannot assess non-use or existence values, and cannot estimate values of resources to non-residents or those who do not purchase property in a given area.

The Travel Cost Model

Outdoor recreation is a major activity in the PES, providing a significant source of economic value to users. Unlike the results of hedonic models, which estimate the use value of resource changes to those who purchase or rent property, travel cost models assess recreational use values associated with natural resources, as realized by both local residents and visitors. Note that there may be some overlap between values estimated by travel cost and hedonic approaches, as a portion of the recreational use value of certain coastal resources may be reflected in residents willingness to pay to live in close proximity to those resources. Given this potential overlap, hedonic and travel cost estimates of value may not be simply "added-up," even though they address largely distinct elements of value. Similar concerns prevent the summation or direct comparison of values from a wide range of nonmarket valuation methodologies (Johnston et al., 2001).

Given the substantial level of outdoor recreation in the PES, the economic value associated with recreational resource use is likely substantial, and human impacts (e.g., pollution) on the natural resources that support such recreation may produce significant economic gains or losses. To address the potential benefits to recreational users from proposed coastal management actions, researchers implemented a recreational use survey during the week of August 22–29, 1995, during which 1,354 surveys were completed.[4] The survey collected activity-specific data on fishing, shellfishing, boating, and swimming in the PES and surrounding waters. Information was also collected on beach use, bird watching, wildlife viewing, and hunting in the five PES towns. Based on the results of this survey, a Travel Cost Model (TCM) was used to estimate the values of swimming, fishing, boating, and wildlife viewing to both residents and visitors. TCM results were also employed to assess the impact of (1) the impact of water quality changes on the number of trips and the value of swimming in the PES, and (2) the effect of the catch rate on the value of recreational fishing.[5]

The TCM estimates the number of recreational trips an average person takes to a specific site, as a function of the cost of travelling to that site, the comparative costs of travelling to substitute sites, and the quality of the recreational experience at the sites. The basis of the model as a means to assess coastal resource values is the assumption that the recreational experience is enhanced by high quality coastal resources (e.g., clean water, abundant recreational fisheries), hence the demand for—and value of—recreational trips depends on resource quality. Although there is no observable market price that would allow one to estimate the value of a recreational activity in a traditional market model, an implicit price can be estimated by adding the cost of traveling to a recreational site (including the opportunity cost of an individual's time) with additional costs of access to the site (e.g., parking fees). Observed recreation choices reveal tradeoffs between the cost of participation, as measured by travel cost, and participation rates, where this relationship is influenced by the quality of natural resource services at recreational sites (Freeman, 1993).

Travel cost models require data on participation rates, cost of travel to sites, and site quality. Participation rate data were collected by the recreational survey. Information regarding travel costs to the target and substitute sites, including the opportunity cost of travel time, was collected from survey data and augmented, as necessary, with distance information gathered from road maps. Water quality data were obtained from field measurements of water quality parameters from the Suffolk County water sampling program. Water quality measures included dissolved nitrogen, coliform counts, water clarity (Secchi disk measurements) and brown tide cell counts. These objective data were supplemented with data from the recreation survey, which asked respondents to provide their subjective evaluation of water quality (excellent, good, fair or poor). The statistical linking of swimmers' subjective perceptions of quality with objective measures of water quality allowed researchers to more accurately model visitors' behavior.[6]

Based on the estimated demand function for recreational visits to a particular site or set of sites (i.e., the travel cost demand curve), the TCM methodology may be used to estimate the consumer surplus or economic use value obtained per person, per trip. In the PES, consumer surplus estimates ranged from $8.59 for swimming to $49.83 for non-residential bird watching and wildlife viewing (Table 1). Fishing and boating values per trip were $40.25 and $19.23, respectively. These estimates of consumer surplus are the average value individuals receive per trip over and above the cost of their recreational trip. That is, they represent unpaid for benefits that individuals receive, on average, from a recreational trip (Freeman, 1993). The relative sizes of these values are consistent with those found elsewhere (e.g. Walsh et al., 1988; Freeman, 1995).

Total annual benefits (access values) for each of the four recreational activities studied are also given in Table 1. The total benefits are estimated by multiplying average consumer surplus for an activity by the estimated total number of trips to engage in that activity during the year (1995).[7] Viewing of birds and wildlife is the most highly valued of the activities studied ($27.3 million). Of the water-based activities, recreational fishing is the most highly valued ($23.7 million).

To illustrate potential policy implications of travel cost model results, consider a hypothetical set of policies that improves all water quality measures by 10 percent in all five PES bays. That is, the policy reduces field measurements of nitrogen, total Coli, and brown tide cell counts by 10 percent and increases Secchi depth by 10 percent throughout the PES. Model results indicate that only swimming is affected by all of the five water quality estimates available, within the range of data available for these variables. Hence, the hypothetical water quality policy illustrated here is restricted to the effects on swimming in the PES.

Based on the TCM, a hypothetical, uniform 10% improvement for all quality measures for all bays would increase the number of annual swimming trips in the PES as a whole by about 151 thousand, and would provide annual benefits of $1.3 million.[8] This represents an increase of about 11% in both use and overall benefits. If maintained for 25 years, this improvement has a present value of $15.1 million, at a discount rate of

Table 1

Total annual value of key recreational activities in the PES (1995 dollars)

	Swimming	Boating[a]	Recreational fishing	Bird watching & wildlife viewing
Total trips/year	1,409,970	937,387	588,493	547,317
Consumer surplus per trip	$8.59	$19.23	$40.25	$49.83
Total annual consumer surplus	$12,113,216	$18,025,952	$23,685,985	$27,272,806

[a]Excludes boating trips taken primarily for fishing.

7 percent.[9] This number represents the change in asset value of the PES for swimming due to the quality improvement, all else remaining the same. Thus, a policy or set of policies that create and maintain such an improvement in water quality would be a good investment of scarce resources if the present value of these costs was less than $15.1 million.

Aside from providing recreational benefit estimates, the TCM may also be used to assess the impact of specific water quality indicators on recreational values, and distinguish among such effects in the various bays of the PES. For example, most of the incremental benefit to swimmers ($752 thousand of the $1.3 million annual benefit) is due to increased water clarity (Secchi depth). The lowest benefit is due to the 10 percent improvement in *E. Coli* counts ($81 thousand per year). This result is particularly notable given that the water quality measure most directly associated with swimmer safety (*E. Coli*) has a lower influence on value than measures of water clarity. Among the five PES bays, the 10 percent uniform water quality improvement has the highest incremental benefit for those who swim in Shelter Island Sound (an annual increase in swimming benefits of $312 thousand) (Table 2).

This simple example illustrates policy information that may be provided through the combination of ecological field measurements (e.g., water quality measurements) and economic recreation demand models. It also illustrates the human impacts—in behavioral and economic terms—of changes in key water quality or ecological indicators. As is the case with the hedonic property value model, the travel cost approach is limited to measurement of use values, in this case use values associated with the recreational use of natural resource services. Although a significant portion of the economic value associated with certain resource services is related to recreational use, in many cases the TCM will only provide a partial view of total value. For example, many resources

Table 2
Travel cost model results: Benefits to swimmers of 10% improvements in each water quality indicator at each PES water body[a]

PES water body[b]	Total Kjeldahl nitrogen	Total coliform	Brown tide cell counts	Secchi disk depth	Water body total
Flanders Bay	$65,278	$71,310	$14,424	$125,753	$276,766
	7,598	*8,300*	*1,679*	*14,637*	*32,215*
Great Peconic Bay	$24,801	$3,522	$48,095	$126,362	$202,779
	2,887	*410*	*5,598*	*14,708*	*$23,603*
Little Peconic Bay	$20,584	$1,140	$70,207	$139,929	$231,860
	2,396	*133*	*8,172*	*16,288*	*26,988*
Shelter Island Sound	$22,598	$4,553	$109,790	$175,093	$312,033
	2,630	*530*	*12,779*	*20,381*	*36,320*
Gardiners Bay	$14,138	$129	$76,863	$185,286	$276,416
	1,646	*15*	*8,947*	*21,567*	*32,174*
PES total	$147,399	$80,653	$319,378	$752,423	$1,299,854
	17,156	*9,387*	*37,175*	*87,581*	*151,299*

[a]All dollar measures are in 1995 dollars; numbers in italics indicate number of trips.
[b]For locations of water bodies, see Figure 1.

provide non-use or existence values or have additional economic use values not associated with recreational use. In these cases, other valuation methodologies may be required to supplement travel cost results, if an estimate of total resource value is desired.

The Wetland Productivity Analysis

Eelgrass, salt marsh, and intertidal mud flats provide a variety of services to the public associated with the ecological productivity of these habitats. For example, improvements to the ecological integrity of these habitats may ultimately lead to measurable increases in the production of fin fish, shell fish, birds and other wildlife. These species may be, in turn, commercially harvested or used for viewing or hunting. In some cases, these productivity values may overlap use values estimated using hedonic models and recreational values estimated using travel cost approaches. In other instances, productivity values may represent a unique class of values not captured by alternative valuation methodologies. However, it is critical to realize that one may not, in general, add productivity value estimates to use values estimated using other methodologies (e.g., hedonic or travel cost methods). To do so would risk double-counting some aspects of value, or measuring the same benefits twice.

For policy purposes, the most useful information is often the value of a small change in wetlands, or the *marginal value*. Marginal value changes may result from a wide range of productivity services of wetlands, and may be valued in the market place (e.g., commercially harvested fish or shellfish), or in nonmarket activities (e.g., bird species used for hunting or viewing). Moreover, wetland services may occur on- or off-site. For example, some wetland services, such as scallop harvests, may occur on-site, while others are realized offsite, for example, when fin fish spawned in a salt marsh are harvested miles away. Hence, the applicability of various components of productivity value depends critically on the choice of groups to be given standing in a particular policy or benefit-cost analysis.

Research in the PES was carried out in collaboration with ecologists (French & Schuttenberg, 1998) and considered two types of wetland productivity gains: (1) the increase in food produced by the habitat which is utilized by higher trophic levels (such as commercially harvested fish and shellfish) in the PES, and (2) the increase in the production of higher trophic levels (e.g., birds) brought about by the increased availability of habitat. These biological gains from restoring or protecting increments of each wetland type (eelgrass, saltmarsh, and intertidal mud flats) are in turn assigned an economic value based on the (1) commercial value of the fin fish and shell fish, (2) the viewing value of birds, and (3) the hunting value of waterfowl ultimately "produced" by wetlands. Although coastal wetlands may provide additional services such as erosion control, our research focused solely on the nursery and habitat services described above.

The approach illustrated here estimates wetland productivity using data specific to the PES. The virtue of this approach is that it captures the underlying biological structure and productivity of PES wetlands, applying biological models and economic values specific to the region.[10] The method—in effect a simulation based on a model of biological functions—side steps some of the data and other problems faced in statistical analyses of wetland economic value, such as those by Lynne et al. (1981), Bell (1989), and Costanza and Farber (1986). However, the method does not allow for statistical tests of significance and relies heavily upon professional judgement to derive estimates. The choice of approach, statistical versus simulation model, is often made based on practical considerations such as the availability of specific types of data.[11]

Two assumptions are critical to the food web and habitat productivity analysis. The first is that food and habitat are biologically limiting factors for the species considered; that is, fish, shellfish and birds depend upon the availability of wetlands, so that small changes in wetlands will cause changes in the populations of these species. The second critical assumption concerns effort and its cost. Fishing, viewing or hunting require the use of labor, capital and other inputs; the net gain from these activities is the benefit (e.g., value of fish landings) minus the costs of the effort required. However, very small changes in the abundance of fish, shellfish or birds due to a small change in wetland areas will lead to only a very slight increase in harvests per unit of effort. Accordingly, to simplify the model, marginal changes in the availability of each wetland category due to preservation or restoration actions are presumed to be small enough so that fishing, hunting, or viewing effort (and hence cost) remains the same. More detailed coverage of the methodology, data, and assumptions used in these types of models is given in French and Schuttenberg (1998).

Food Web Estimates

To estimate the economic value of food-web effects, several pieces of information are required. First, it is necessary to quantify the amount of food produced by a habitat. Primary (plant) and bottom (amphipods, worms, etc., in and on the sediments) production rates were estimated for PES wetland categories, using results from the ecological literature (French & Shuttenberg, 1998). The fraction of the additional production passed up through the food web is estimated. This additional production is translated into eventual commercial fin fish and shell fish production and landings using average relationships estimated across numerous estuaries by Nixon (1982). Finally, the estimated fish and shell fish landings are valued using species-specific fishery values for PES landings. Details of all calculations are given in French and Schuttenberg (1998).

Habitat Estimates

Habitat values are estimated for species (bay scallops, blue crab, softshell clams, and birds) with human use values. Habitat values are based on (1) the expected yield of fish or shellfish dependent upon the habitat, and (2) the abundance of wildlife (birds) that utilize the habitat. Fish and shellfish values are commercial values based on market sales. Wildlife values are related to nonmarket hunting (waterfowl) and viewing (wading birds).

Different aspects of a wetland habitat are critical for different species. For example, bay scallops depend upon eelgrass as nursery habitat for juveniles. The grass provides a refuge from predators for juvenile scallops. It is assumed that eelgrass is a limiting factor for scallops, so that the entire PES scallop fishery depends upon eelgrass beds. Blue crab use salt marsh and eelgrass habitats preferentially. Again, it is assumed that the entire blue crab fishery depends upon the salt marsh and eelgrass beds of the estuary. Soft shell clams prefer intertidal mud flats and sand flats. Soft shell clams are assumed to all have been produced in intertidal mudflats and shoals in the PES. Abundance of birds depends upon habitat type.

An average abundance per unit area of habitat is assumed, based on the results for the coastal area including the PES, as given in the Natural Resource Damage Assessment Model (Version 2.4, April, 1996) developed by the authors for the US Department of the Interior (Applied Science Associates et al., 1996). Birds that are specifically benefited by salt marsh, eelgrass or mud flats were included in the present analysis. These species are waders (herons, egrets, and ibis), shorebirds, brant and black ducks.

Waders use all three of the habitat types, while shorebirds use marsh and mud flats. Brants specifically feed on eelgrass. Black ducks are known to require structured habitat, including both marsh and eelgrass. The value of fish and shellfish is based on commercial harvest values. The marginal value of bird species usage of the habitat is based on the benefits human receive from viewing or hunting (waterfowl) birds. The values per animal per year are proportional to the number of viewing trips and the rareness of the species in the local area.

Productivity Value Results

Productivity value estimates include both values due to food web productivity and values related to habitat. Results are provided for the (1) Marginal value of existing wetlands, and (2) the marginal value for restored wetlands (Table 3). Two values are calculated: An annual value and an asset value. The annual value is the sum of the food web values and the habitat values for a year. Asset values were calculated by discounting the annual value over a 25 period using a discount rate of 7 percent, the same time frame and discount rate used elsewhere in this report.[12]

Based on productivity model results (Table 3), the marginal asset values of PES wetlands appear to be substantial, especially in light of the fact that other services wetlands may provide, such as protection from erosion and storms, aesthetics, and existence value, are not considered. Productivity results also indicate substantial variance in ecological productivity values provided by different coastal ecosystem types. For example, study results indicate that eelgrass productivity values ($1,065 per acre/year) exceed those for salt marshes ($338 per acre/year) by nearly a factor of 3, and exceed those for intertidal mud flats ($67 per acre/year) by greater than a factor of fifteen. Restored wetlands have a lower value than existing wetlands since it may take years for an existing wetland to become fully functional.

As is the case with any valuation methodology, the policy questions under consideration can influence the relevance of particular value estimates. For example, the value for existing wetlands would be most applicable to policy issues dealing with preservation decisions. Results regarding created habitats are most relevant assessing wetland restoration policies.

Table 3
Marginal vaules of PES wetlands (1995 dollars)

	Existing habitats		Created habitats		
	Annual value per acre[a]	Asset value per acre[b]	Years to become fully functional[a]	Asset value per acre[b]	Estimated number of acres in PES (millions)
Wetland type					
Eelgrass	$1,065	$12,412	10	$9,996	6.04
Saltmarsh	$ 338	$ 4,291	15	$3,454	13.51
Inter-tidal mud flat	$ 67	$ 786	3	$ 626	14.05

[a]French and Schuttenberg (1998) estimate habitat values using a discount rate of 3% and time horizon of 25 years. Our use of 7% and 25 years reduces the estimated wetland values by over one half.

[b]Using a discount rate of 7% and a time horizon of 25 years. Assumes linear recovery to full (99%) restoration over the period estimated by French and Schuttenberg (1998). French and Schuttenberg used a sigmoid function to approximate the time path of recovery.

The Resource Value (Contingent Choice) Survey

As presented above, the hedonic property value study captures the value of amenities or dis-amenities to nearby property owners, the recreation study estimates use value for key outdoor recreational activities, and the wetlands productivity study yields estimates of the value of wetland ecosystems in the production of fish, shell fish, and birds. However, none of these studies reflects the value the public holds for the general character or ambience of the PES—the "sense of place" it provides, defined in large part by the quality and characteristics of the local environment. The PES Resource Value survey uses original contingent choice survey results to estimate relative preferences that residents and second homeowners have for preserving and restoring key PES natural and environmental resources. The primary goal of the survey was to learn about the public's preferences, priorities, and values for the environmental and natural resources of the Peconic Estuary that might be affected by preservation and restoration actions. Other important goals were to create a survey that (1) would minimize some of the problems often associated with valuation surveys; (2) would be easily understandable to members of the public; and (3) could be answered in a reasonable amount of time.

The contingent choice survey format asks respondents to choose between bundles of public commodities, which differ across their physical, environmental, aesthetic, and/or money dimensions (Swallow et al., 1994). For example, respondents might compare two environmental policy proposals, each with a different impact on coastal resources and a different money cost. By analyzing choices of respondents (i.e., preferences) for a variety of potential policies, it is possible to estimate respondents' relative values for environmental commodities (or policy results), and their willingness to trade-off elements of policy packages (Cameron, 1988; Hanemann, 1984; Johnston et al., 1999; Swallow et al., 1994). In order to assess money-denominated welfare effects, or willingness-to-pay, the considered commodities or policies must include a money (cost or revenue) component. However, if one is solely interested in estimating rates of in-kind tradeoff or substitution, then money elements need not be present.

The resource survey was developed over a six-month period, from February to August 1995, in an extensive process that included individual interviews, focus groups, and pretests of preliminary versions of the survey. To ensure coordination of the survey with existing scientific and technical studies, and with potential policy actions, survey development was preceded by meetings with various groups of science and policy experts. These included members of the PES Management Committee; the Chairman of the PES Citizens' Advisory Group; a representative of the Nature Conservancy; a biologist from the NY State Department of Environmental Conservation; a marina owner who was head of the local Marine Trades Association; a commercial fisherman who represented the Long Island Inshore Trawlermen's Association; and representatives of various other stakeholder, business, and environmental groups.

Based on concerns expressed by participants in focus groups, and natural resources identified as important by the Technical Advisory Committee, five natural resources were selected to be addressed by the survey: (1) farmland, (2) undeveloped land, (3) wetlands, (4) shell fishing areas, and (5) eelgrass. The objective of the survey was to determine respondents' values for improvements in natural resources above a specified baseline level. This was defined as the level that would exist in the year 2020, if no action were taken to preserve or restore the resource. We determined the baseline in consultation with the Technical Advisory Committee, based on historical declines and the judgment of experts, for each resource. In the contingent choice questions, each resource was included at three different levels: The projected level for 2020 (the "no new action," or baseline, scenario), and two levels associated with hypothetical programs that would preserve or restore the resource. Respondents were asked to choose which of these three policy options was preferred, given the program cost and associated changes in PES resources.

Based on responses to contingent choice questions, the statistical model calculates the relative weights, or values, for an additional acre of each natural resource, and for an additional dollar of cost to each resident or second homeowner household. These weights are measured by the estimated coefficients. From these coefficients, relative values for the different resources, and dollar values for protecting an additional acre of each resource, can be calculated as described by Hanemann (1984) and Opaluch et al. (1999).

The results for two different models are reported in Table 4.[13] Model results indicate that the order of priorities for protection or restoration of resources is as follows: farmland, eelgrass, wetlands, shellfish, and undeveloped land. The presentation of two sets of statistical results allows researchers to assess the role of symbolic values in survey results. Symbolic values are often an issue for both contingent valuation and contingent choice methods, and are characterized by survey responses that express the importance of improving or protecting the environment in general, instead of values for specific levels of natural resources. For example, a survey might ask respondents to state how much they would be willing to pay to protect particular species of birds from oil spills. A person answering the survey may not care about these birds, but may state a positive willingness to pay because they think that oil spills should be prevented. Thus, their response may not reveal the value of the affected birds, per se. Model 1 (a standard, conditional logit model) does not account for the possibility of symbolic effects,

Table 4
Resource survey estimation results: Annual values per household and per acre (1995 dollars)

	Coefficient	Value/ acre/hh/ year	95% confidence interval[a]		Avg. value acre/year[b]
Model 1:[c]					
Farmland	0.000511	$0.136	$0.122	$0.150	$9,979
Undeveloped land	0.000107	$0.028	$0.025	$0.032	$2,080
Wetlands	0.000336	$0.089	$0.079	$0.100	$6,560
Shellfish areas	0.000233	$0.062	$0.053	$0.071	$4,555
Eelgrass	0.000419	$0.111	$0.098	$0.125	$8,186
Cost	–0.003765				
Model 2:[d]					
Program B	–0.1586				
Farmland	0.000300	$0.087	$0.073	$0.101	$6,398
Undeveloped land	0.000056	$0.016	$0.013	$0.019	$1,203
Wetlands	0.000228	$0.066	$0.056	$0.077	$4,863
Shellfish areas	0.000128	$0.037	$0.031	$0.044	$2,724
Eelgrass	0.000281	$0.082	$0.069	$0.094	$6,003
Cost	–0.003441				

[a]The 95% confidence interval indicates the range within which the "true" value is likely to fall, with a 95% probability.

[b]Calculated based on 73,423 households.

[c]Conditional Logit model.

[d]Nested Logit model. The program specific constant term represents a difference in intercept between Program A and Program B. It indicates that respondents were less likely to choose Program B, *ceteris paribus*. In this instance, holding all else ocnstant, 55% of respondents would choose Program A versus 45% choosing Program B.

while Model 2 (a nested logit model) provides a correction for such values. It does this by separating the probability of taking action vs. no action from the probability of selecting either Program A or Program B.

Estimated dollar values for PES resources range from around $2.1 thousand per acre per year for undeveloped land, to around $10 thousand for farmland for Model 1; and around $1.2 thousand to $6.4 thousand for Model 2. The values from Model 2 may be interpreted as the portion of respondents' willingness to pay to take action which can be attributed to the described changes in natural resource levels. This is smaller than the estimated values in Model 1, which includes a "symbolic" effect supporting taking of action in general to protect the environment, rather than the value of the specific resources being provided. As illustrated by Table 4, the estimated dollar values for Model 2 are approximately half to two-thirds as large as those estimated from Model 1.

Although the estimated dollar values differ, both models result in the same ordering of priorities and relative values for the natural resources. These results indicate that priorities and relative values are robust with respect to different model specifications, and are independent of symbolic effects, but that the estimated dollar values vary somewhat, although they are similar in magnitude. Therefore, it may be concluded that the model is relatively robust to different specifications, and that the proportion of value that is symbolic is not great. In the corrected model, estimated annual values per acre, per household, per year range from $0.016 per acre for undeveloped land to $0.087 per acre for farmland. Multiplied by the number of households in the PES, total values per acre per year range from $1,203 per acre for undeveloped land to $6,398 per acre farmland. Discounted over 25 years at a 7% discount rate, the result is a total discounted value of $14,024 per acre for undeveloped land and $74,562 per acre for farmland (Table 4).

Implications and Discussion

Table 5 summarizes relationships among major classes of nonmarket value measured in the Peconic Estuary system, and methodologies appropriate for their measurement.

Table 5
Methodologies for nonmarket valuation

	Type of nonmarket value/method of measurement[a]			
Group realizing value	Recreational use values	Nonrecreational quality of life and aesthetic values (related to resource services)	Consumptive values (natural goods produced by coastal habitats)	Nonuse or existence values
Permanent residents	*TCM*; Hedonic; PVM; CVM	*Hedonic; CVM*	*PVM*; CVM TCM	*CVM*
Seasonal residents	*TCM*; Hedonic; PVM; CVM	*Hedonic; CVM*	*PVM*; CVM TCM	*CVM*
Short-term tourists	*TCM*; PVM CVM	*CVM*	*PVM*; CVM TCM	*CVM*

[a]Methods in italic type are principal methodologies used to measure the value in question. Methods listed in plain type may measure some aspects of the value in question, but will likely capture only a small portion of the total value. TCM = Travel Cost Model; Hedonic = Hedonic Property Value Model; PVM = Productivity Value Model; CVM = Contingent Valuation or Contingent Choice Model.

Of particular note are the areas of overlap among values estimated using different methodologies, and differences among resident and non-resident groups who may realize particular nonmarket values. Although the scope of this presentation prevents a full discussion of the details of each nonmarket methodology, it does provide an indication of the types of resource services which may be estimated, and the basic mechanics of each approach. It also highlights the fundamental assumptions of each method, and the general magnitudes of economic impact which may be expected. Finally, it makes the novel contribution of illustrating the results of a range of studies conducted for the same coastal region—allowing comparison of the various nonmarket values which are associated with the same resource services, in the same coastal area.

Within each nonmarket study (i.e., hedonic, travel cost, wetland productivity, contingent choice) the estimated values associated with specific coastal resources are not particularly surprising, given similar results in the resource economics literature (e.g., Parsons, 1992; Mitchell & Carson, 1989; Correll et al., 1978; Chicoine, 1981; Smith et al., 1986; Lynne et al., 1981; Kahn & Kemp, 1985; Walsh et al., 1988). However, unlike prior studies, the presented combination of results allows new insights regarding the different types of nonmarket values that may be generated by different classes of coastal resources, and allows explicit recognition of areas of potential overlap among values estimated using different methodologies.

Results illustrated for the PES also illustrate cases in which valuation methodologies used in isolation may lead to misleading or incomplete policy conclusions. For example, the positive value of farmland in contingent valuation studies is well-established in the literature (e.g., Beasley et al., 1986; Kline & Wichelns, 1998). However, the combination of contingent valuation and hedonic results for the same region (as presented above) suggests that assessment of coastal farmland values may be more complex than is generally assumed. In this case, hedonic property value results indicate a *negative* value of farmland—despite the *positive* value illustrated by the contingent choice results (Johnston et al., 2001). This seemingly contradictory pair of results provides policy insight unavailable though either study in isolation. In this case, it suggests that landowners in close proximity to farmland may indeed have negative *use values* for this land use, related to such negative amenities as farm odors, noises, and other nuisances associated with agricultural landscapes (American Farmland Trust, 1997). However, the average coastal community resident has a positive total value for farmland, including *use values* related to viewing agricultural landscapes and *non-use* (existence) *values* for farmland, as reflected in contingent choice results (Beasley et al., 1986). Where a hedonic study in isolation might highlight a negative aspect of farmland value, and a contingent choice study in isolation might highlight an average positive value, a combination of the two studies will illustrate a more realistic scenario characterized by heterogeneous values for farmland among different resident groups. These findings are discussed in greater detail by Johnston et al. (2001).

Although coastal farmland provides a clear example of the benefits of multiple approaches to economic analysis in a single coastal region, a multi-methodology approach may provide policy insights regarding a wide range of coastal resources. For example, comparisons of travel cost model results to those from a contingent valuation study might help policy makers assess approximate differences in social values that would result from improvements in water quality (for recreational purposes) from those that would result from, for example, preservation of farmland. One may also use multiple studies to assess equity considerations—the distribution of policy benefits across user groups. For example, hedonic studies may indicate benefits of specific resource changes to local property owners, where travel cost studies indicate benefits received by recreationists—including permanent residents, summer residents, and tourists. Where contingent choice results estimate the values of the average survey respondent (including both residents and visitors), the wetland productivity study (as applied) estimates benefits to those who supply and consume associated fish and shellfish products. Comparisons of results from different methodologies not only help identify the magnitude of total benefits, but also help identify groups who benefit from policy actions.

Although multiple studies can provide information of broader relevance and scope than any single study in isolation, researchers must use caution when combining the results of different nonmarket valuation methodologies. For example, a proportion of the value stated for eelgrass and shellfish areas in the contingent choice survey likely overlaps with the wetland productivity values calculated using ecological-economic simulation models. Similarly, recreational use values may be measured using travel cost methodologies, yet may also influence the value of local homes (e.g., residents may wish to live in close proximity to valued recreational resources), thereby influencing hedonic property value estimates. In these and many other cases, summing of value estimates from different methodologies may double-count the same values.

In conclusion, nonmarket valuation methodologies can measure a wide range of potential values that do not appear in more typical market-based economic impact analysis. Moreover, different methodologies will provide estimates of different types of resource values. Improved knowledge of the existence, assumptions and outputs of different methodologies can help managers assess whether nonmarket valuation methods will provide relevant information, and which specific approaches are appropriate to given policy scenarios. Although multi-dimensional combinations of studies (such as the suite of studies conducted for the Peconic Estuary) will provide the most broad scope of economic information, funding considerations often prevent such large scale research. In such cases, managers must choose a research agenda that is most appropriate given the set of resources and resource services under consideration.

Notes

1. Originally we intended to carry out a property value study for all five PES towns, but sufficient data could only be obtained for Southold.

2. A well-documented example of the relationship among environmental amenities and property values is open space. Many studies show that open space increases the price of nearby property, reflecting home buyers' values for the services and character offered by this resource (e.g., Bockstael 1996; Garrod & Willis, 1992; Johnston et al., 2001; Parsons, 1992).

3. The hedonic price model employs a transcendental or trans-log functional form. The characteristics of this functional form are provided by Chicoine (1981). Other functional forms were also considered, but did not perform as well as the transcendental form (Johnston et al., 2001).

4. The recreation survey was administered to a convenience sample of residents, second homeowners, and day trippers using an intercept survey approach. Considerable efforts were made to select public (e.g., post offices, centrally located streets, beaches and parks) and private (e.g., malls) locations throughout the study in order to capture a representative cross section of potential respondents. The week selected, August 22–29, was not atypical of the high summer season in the PES with respect to weather or special events.

5. Swimming and recreational fishing are major estuary activities for which the number of trips and their economic value depend upon environmental and resource quality (e.g., McConnell & Strand, 1996; Bell & Leeworthy, 1990). For these reasons, swimming and recreational fishing were the focus of our efforts to estimate the recreational benefits of management actions that would improve estuary water quality.

6. Initial travel cost demand functions were estimated as a function of, among other variables, the subjective water quality ranks provided by respondents (excellent, good, fair, poor). An ordered logit model (Maddala, 1983, pp. 46–49) was then used to forecast these subjective water quality ratings as a function of an objective brown tide index, a nitrogen-bacteria index, and Secchi disk

depth readings. This ordered logit water quality model allows one to forecast the effect of an objective water quality change (e.g., change in Secchi depth) on average subjective water quality ratings, and hence on the expected number of trips, per person, to any particular site.

7. The total participation (i.e., number of trips) for each activity was estimated by extrapolating the number of trips respondents identified in the Recreational Use Survey to the population of residents, second home owners, and overnight visitors. The population of residents and second home owners was estimated based on 1990 census data. The population of overnight visitors was extrapolated based on the proportion of overnight visitors in the survey sample. For additional details, see Opaluch et al. (1999).

8. Note that this number does not account for the potential cost of programs that would increase water quality; only benefits are estimated here.

9. It is recognized that increases in population would increase benefits, as would decreases in the discount rate used and increases in leisure time (and likely in income).

10. A similar approach by Pornpinatapong (1997) employed the results in the Natural Resource Damage Assessment Model (Applied Science Associates et al., 1996) to estimate the asset value of coastal wetland services in the Northeast.

11. A reviewer correctly notes that these two approaches are not mutually exclusive. Given sufficient funding and data one could conduct both methods at any given site.

12. Use of lower discount rate and longer time horizon would lead to a larger value. The choice of the "correct" discount rate for benefit-cost analysis of public projects frequently raises nettlesome issues (Boardman et al., 2001). This is particularly true when the value being discounted (e.g., consumer surplus) is not available for investment elsewhere in the economy. In such cases, discount rates based on a social time preference argument are often considered most appropriate. In this application a 7% discount rate is used, approximating long-term, federal borrowing rates. However, we recognize that this choice may over- or understate the true social discount rate, and hence discounted non-market values.

13. Model 1 is the standard conditional logit model, and Model 2 is the nested logit model.

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